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Vol. 7, No. 3 SEPTEMBER, 1918

THE SCIENTIFIC MONTHLY

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A Remarkable Textbook

Barber's First Course in General Science

By FREDERICK D. BARBER, Professor of Physics in the Illinois State Normal University, MERTON L. FULLER, Lecturer on Meteorology in the Bradley Polytechnic Institute, JOHN L. PRICER, Professor of Biology in the Illinois State Normal University, and HOWARD W. ADAMS, Professor of Chemistry in the same. vii+588 pp. of text. 12mo. $1.25.

A recent notable endorsement of this book occurred in Minneapolis. A Committee on General Science, representing each High School in the city, was asked to outline a course in Science for first year High School. After making the outline they considered the textbook situation. In this regard, the Committee reports as follows:

"We feel that, in Science, a book for first year High School use should be simple in language, should begin without presupposing too much knowledge on the part of the student, should have an abundance of good pictures and plen[illegible] of material to choose from.

Barber's *First Course in General Science* seems to us to be[illegible] meet these requirements and in addition it suggests materials for home experiments requiring no unusual apparatus, and requires no scientific measurements during the course. We recommend its adoption."

Other Interesting Opinions on the Book Follow:

SCHOOL SCIENCE AND MATHEMATICS:—It is one of the very best books on general science that have ever been published. The biological as well as the physical side of the subject is treated with great fairness. There is more material in the text than can be well used in one year's work on the subject. This is, however, a good fault, as it gives the instructor a wide range of subjects. The book is written in a style which will at once command not only the attention of the teacher, but that of the pupil as well. It is interesting from cover to cover. Many new and ingenious features are presented. The drawings and halftones have been selected for the purpose of illustrating points in the text, as well as for the purpose of attracting the pupil and holding his attention. There are 375 of these illustrations. There is no end to the good things which might be said concerning this volume, and the advice of the writer to any school board about to adopt a text in general science is to become thoroughly familiar with this book before making a final decision.

WALTER BARR, *Keokuk, Iowa:*—Today when I showed Barber's Science to the manager and department heads of the Mississippi River Power Co., including probably the best engineers of America possible to assemble accidentally as a group, the exclamation around the table was: "If we only could have had a book like this when we were in school." Something similar in my own mind caused me to determine to give the book to my own son altho he is in only the eighth grade.

G. M. WILSON, *Iowa State College:*—I have not been particularly favorable to the general science idea, but I am satisfied now that this was due to the kind of texts which came to my attention and the way it happened to be handled in places where I had knowledge of its teaching. I am satisfied that Professor Barber, in this volume, has the work started on the right idea. It is meant to be useful, practical material closely connected with explanation of every day affairs. It seems to me an unusual contribution along this line. It will mean, of course, that others will follow, and that we may hope to have general science work put on such a practical basis that it will win a permanent place in the schools.

Henry Holt and Company

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thank art and literature for some of the greatest benedictions of life. But to value their treasures, it certainly can not be necessary to be ignorant of the laws of nature. It is impossible to see why a man should be less inspired or generous because he knows more. On the contrary, the better a man knows nature, the better will his heart vibrate at the touch of any true beauty. All other things remaining the same, his generosity, his inspiration will directly depend upon the amount and the quality of his knowledge.

The whole contest has been constantly obscured by the fact that it has been generally discussed and settled by literary people, impervious to scientific thought. How could they judge the relative merits of chemistry and Greek? What did they know of it? Yet they were the final judges. It is well known that most university presidents (and trustees) are literary people or lawyers. A generation or two ago they were chiefly theologians. But are literary people not just as unfit for intellectual leadership as theologians? They see only with one eye. The publications of the members of their scientific departments are just as unintelligible to them as if they were written in Chinese. How could these university presidents coordinate activities which they fail to understand? Their function becomes more and more a mere administrative one; they can not possibly be—what they should be—the inspirers, the spiritual guides of the faculty.

The whole thing becomes tragic when we realize that one of the most urgent tasks of our time, namely, to reconcile knowledge and idealism, is chiefly entrusted to them. We need both equally. I do not know which is worst, knowledge without idealism or idealism without knowledge, and yet our whole system of education is leading to their growing estrangement. It is clear that university presidents and trustees could do more than any other people towards the accomplishment of this task, if they were equal to it. In truth, a literary president is as hopeless as a blind admiral.

How long will it take to accomplish this educational revolution? I do not know. The struggle promises to last a considerable time. Think of the immense inertia incorporated in the present alliance of literary people, historians, philosophers; of the enormous weight added to it by the ignorance of the rulers, legislators, publicists, newswriters and of the great bulk of the teachers—all these men continually playing upon the religious and moral feelings of the people. Think of the united strength of tradition, superstition and ignorance. Moreover

literary studies will always appeal more than any other to the mass, because they require less intellectual effort. Most people are very reluctant to use their brains; strange as it may seem, not a few find it easier to die than to think.

On the other hand, most scientists are so busy, so absorbed by their own research work, and—it grieves me to add—many have become so dull by dint of premature and extreme specialization that they do not try to get control of educational matters. They do not care any more; they are generally quite happy when a bone is thrown to them in the form of a new laboratory. Of course, business people now begin to understand that to equip a laboratory for physical or chemical, not to speak of medical, research is a sound investment. But how long will it last before they understand not simply the practical, the material value of science, but also its beauty, its greatness? Millionaires and city councils begin to appreciate art museums; but when will they see that there is also an infinite amount of unexplored beauty and fresh inspiration in the realm of science—and that it is high time to dig it out and to let more people, including the scientists themselves, partake of it?

No essential progress in the management of human affairs can be expected so long as the scientific methods and the scientific spirit are not more systematically applied to them. My own efforts are passionately bent on explaining that the brute knowledge of uneducated experts, precious as it may be from a purely material standpoint, would, notwithstanding, be a source of danger to our civilization. What is the use of being efficient, if we are to lose thereby all the joy, happiness and freedom which we need even more than bread? Yet, if we wish to survive, we must be efficient.

Idealism alone is blind and powerless; knowledge without compensation is brutal. We need the golden combination of both. To reconcile efficiency and happiness it is necessary and sufficient that science remain closely allied with beauty and charity. The establishment of this alliance is the whole program of the New Humanism.

Short Bibliography

Two elementary text-books on the history of science have been published in America last year: Walter Libby's "Introduction to the History of Science" (Boston, Houghton Mifflin) and Sedgwick and Tyler's "Short History of Science" (New York, Macmillan). A more elaborate text-book —the best that we have thus far, however imperfect it may be—is Friedrich Dannemann's "Die Naturwissenschaften in ihrer Entwicklung und

in ihrem Zusammenhange," 4 vols., Leipzig, 1910.3. Aldo Mieli has begun the elaboration of a much vaster work, "Storia del pensiero scientifico dalle origini a tutto il secolo XVIII." One volume only has been published: "Le scuole ionica, pythagorica ed eleata," Firenze, 1916 (the author proposes to study the earlier periods later). Two other volumes are ready, but their publication is suspended on account of the war. Mieli is the most active representative of the New Humanism in Italy.

A splendid movement has been launched in Oxford by Dr. and Mrs. Charles Singer, Sir William Osler and others. They have just published the first volume of their "Studies in the History and Method of Science," Clarendon Press, 1917. This offensive is gallantly supported by F. S. Marvin, the author of "The Living Past" (Oxford, 1913), a little masterpiece of historical interpretation. Marvin has edited two other books: "The Unity of Western Civilization" and "Progress and History" (Oxford, 1915–6). See also his article on "Science and History" in *The Contemporary Review*, April, 1918.

Since I have quoted Marvin's work, I should also quote James Harvey Robinson's comprehensive and generous "Outline of the History of the Intellectual Class in Western Europe," New York, 1915, containing copious bibliographical information on the history of thought.

Ph. E. B. Jourdain has contributed many papers on the history and philosophy of science (chiefly mathematical) to *The Monist* (Chicago), of which he is one of the editors, and to the other reviews quoted below. Eugenio Rignano, editor of *Scientia*, international review of scientific synthesis (Bologna), and Sir Ronald Ross have done much also to promote these studies. It is invigorating to read Sir Ronald's caustic and spirited editorials in *Science Progress*, a quarterly review of scientific thought, work and affairs (London). A collection of Rignano's papers has just been translated into English: Essays in scientific synthesis, London, 1918. George Sarton, editor of *Isis*, revue internationale consacre â l'histoire de la science (Wondelgem, Belgium), has published many papers in his own review (1913–4), also in the *Revue générale des Sciences pures et appliquées*, Paris, 1912; in *The Monist*, July, 1915; in *Scientia*, 1918, and in *Science*, 1917 (An institute for the history of science and civilization, Vol. 45, p. 284.6; Vol. 46, p. 399–402). It is not a mere coincidence that each of the four last-named writers is, or was, the editor of a review devoted to scientific synthesis. Many other papers on the humanization of science have also been published in *Science*, New York, and still more in *Nature*, London.

For further bibliography, see Aksel G. Josephson, "Books on the History of Science," The John Crerar Library, Chicago, 1911; Supplement to December, 1916, *ibidem*, 1917.—Aldo Mieli, "La storia della scienza in Italia. Saggio di bibliografia di storia della scienza," Firenze, 1916.

Concerning teaching in the U. S., see Fred E. Brasch, "The Teaching of the History of Science. Its Present Status in Our Universities, Colleges and Technical Schools," *Science*, Vol. 42, p. 746–60, 1915. I would suggest that any new initiative in this field be communicated to F. E. Brasch, The John Crerar Library, Chicago, to enable him to keep the information up to date for the benefit of all concerned.

G. S.

BAKER ON THE MICROSCOPE AND THE POLYPE

By Professor LORANDE LOSS WOODRUFF

YALE UNIVERSITY

THE transactions of learned societies during the eighteenth century are replete with microscopical observations instigated directly or indirectly by the pioneer work of Hooke and Grew in England, Leeuwenhoek and Swammerdam in Holland, and Malpighi in Italy. In particular, Leeuwenhoek's long series of letters, published year after year chiefly in the *Philosophical Transactions* of the Royal Society of London, revealed an undreamed-of microcosm beyond the ken of unaided vision and turned the attention of the "Ingenious and Curious," the philosopher and dilettante, to the slowly developing microscope as a source of pleasure or fame. Among the English disciples of Leeuwenhoek, it was Henry Baker, of London, on whom seems to have fallen the Dutch microscopist's mantle—though, it is true, considerably reduced.

Baker was born in London on May 8, 1698, and began his career at an early age as a bookseller's apprentice. In 1720 he undertook to tutor a deaf and dumb child and with such success that he established a private school in London for deaf mutes. His course of instruction comprised speech and lip reading, writing and drawing, but the essential point of his system, which unfortunately he felt constrained to keep a secret, was that, after the preliminary training, he took his pupils on rambles about London and instructed them by conversation on the events of everyday life with which they came in contact. Baker realized a considerable fortune from his school, and the success of his method brought him to the attention of Daniel Defoe, who in 1728 became associated with him in founding the *Universal Spectator and Weekly Journal.* The following year Baker married Defoe's youngest daughter, Sophia, who bore him two sons. He survived both his wife and children, his sole heir being a grandson. After Baker's death on November 25, 1774, the Royal Society established the Bakerian Lecture with a fund given by him for discourses on "anatomical or chymical" subjects.

Baker's first essay as an author was "The Invocation of

Health," which was published without his sanction in 1723. The same year appeared a pamphlet of "Original Poems: Serious and Humorous," printed for the author, and was followed in three years by the "Second Part of Original Poems: Serious and Humorous." In 1727 was published his philosophical verses entitled "The Universe. A Poem intended to restrain the Pride of Man." This was printed for T. Worrall at Judge Coke's Head, against St. Dunstan's Church, in Fleetstreet, and sold for one shilling. "The Universe," as its subtitle indicates, is an attempt to impress the reader with the vastness and grandeur of nature and the folly of insignificant man believing that it was created for his especial edification. This poem, which attained considerable popularity and was frequently quoted, reminds one of the poetical works of Erasmus Darwin. An idea of the whole may be gathered from the following extract, which is one of the most interesting, and apparently one which Baker especially approved since he quoted it before the Royal Society—the first instance of original versification appearing in the *Philosophical Transactions*—and again nearly twenty years later in "The Microscope Made Easy":

> Each Seed includes a Plant: that Plant, again,
> Has other Seeds, which other Plants contain:
> Those other Plants have all their Seeds; and Those,
> More Plants, again, successively inclose.
>
> Thus, ev'ry single Berry that we find,
> Has, really, in itself whole Forests of its Kind,
> Empire and Wealth one Acorn may dispense,
> By Fleets to sail a thousand Ages hence:
> Each Myrtle-Seed includes a thousand Groves,
> Where future Bards may warble forth their Loves.
> So ADAM'S Loins contain'd his large Posterity,
> All People that have been, and all that e'er shall be.
>
> Amazing Thought! what Mortal can conceive
> Such wond'rous Smallness!—Yet we must believe
> What Reason tells: for Reason's piercing Eye
> Discerns those Truths our Senses can't descry.

During the next decade Baker published two volumes entitled "Medulla Poetarum Romanorum" and also a translation of Molière; but his name has been preserved from oblivion almost solely by his two volumes, "The Microscope Made Easy" and "Employment for the Microscope," which exploited the compound microscope.

> For Many have been frightened from the Use of it, by imagining it required great Skill in Optics, and Abundance of other Learning to comprehend

it to any Purpose: whereas nothing is really needful but good Glasses, good Eyes, a little Practice, and a common Understanding, to distinguish what is seen; and a Love of Truth, to give a faithful Account thereof. Others have considered it as a meer Play-thing, a Matter of Amusement and Fancy only, that raises our Wonder for a Moment, but is of no farther Service: which Mistake they have fallen into, from being unacquainted with any Principles whereby to form a right Judgment of what they see. Many, again, have laid the Microscope aside, after a little Use, for want of knowing what Objects to examine, where to find, how to prepare, and in what Manner to apply them. The trouble of managing it has also frighted some. . . .

The likeliest Method of discovering Truth, is, by the Experiments of Many upon the same Subject; and the most probable Way of engaging People in Such Experiments, is, by rendering them easy, intelligible, and pleasant. To effect this, is my Endeavor in the following Treatise. . . .[1]

"The Microscope Made Easy" was dedicated to the Royal Society and, receiving its imprimatur in 1742, was published by the famous London bookseller, Robert Dodsley.

Where Tully's bust and honour'd name
Point out the venal page,
There Dodsley consecrates to fame
The classics of his age.[2]

The book's popularity is attested by the fact that a second edition, with some additions, appeared the following year, and later editions, unchanged, in 1744, 1754, 1769, 1785, etc., not to mention the translations into foreign languages. The scope of the work is given *in extenso* on the title page (*cf.* Fig. 1).

The spirit of the eighteenth century which called forth Baker's volumes is well expressed in the Introduction:

In this inquisitive Age, when the Desire of Knowledge has spread itself far and wide, and we sit not down contented, as heretofore, with the Opinions of ancient Times, but resolve to examine for Ourselves, and judge from our own Experience; it may not, perhaps, prove unacceptable to point out some proper Subjects of Enquiry.

The Works of Nature are the only Source of true Knowledge, and the Study of them the most noble Employment of the Mind of Man. Every Part of the Creation demands his Attention, and proclaims the Power and Wisdom of its Almighty Author. The smallest Seed, the minutest Insect, shews the Skill of Providence in the Aptness of its Contrivance for the Purposes it is to serve, and displays an Elegance of Beauty beyond the utmost Stretch of Art.

The Wise in all Ages have been sensible of this Truth; and, as far as they were able, have studied and enquired into the Recesses of Nature; but for Want of proper Helps have frequently been mistaken. As certain Principles must first be learned ere we can become Masters of any Science, so in the School of Nature, we must begin with the *Minutiæ*, the smallest and most uncompounded Parts, ere we can understand the larger and more considerable. . . .

[1] "The Microscope Made Easy," Dedication.

[2] *London newspaper*, 1756.

That Man is certainly the happiest, who is able to find out the greatest Number of reasonable and useful Amusements, easily attainable and within his Power: and, if so, he that is delighted with the Works of Nature, and makes them his Study, must undoubtedly be happy; since every Animal, Flower, Fruit, or Insect, nay, almost every Particle of Matter, affords him an Entertainment. Such a Man never can feel his Time hang heavy on his Hands, or be weary of himself, for want of knowing how to employ his Thoughts: each Garden or Field is to him a Cabinet of Curiosities, every one of which he longs to examine fully; and he considers the whole Universe as a Magazine of Wonders, which infinite Ages are scarce sufficient to contemplate and admire enough. . . .

All these, and numberless Wonders more, the MICROSCOPE can exhibit to us. I shall therefore proceed to describe this noble Invention, shew how far it is improved at present, give a brief Account of what Discoveries have been made, and point out some Objects for the Curious to examine by it. In doing this, I shall avoid as much as possible all Affectation of Learning, or Expressions that are not in common Speech, being desirous that every body may understand me.

The author, then, in Part I. of the book, first describes and illustrates in succession the Single Microscope and a new invention for "giving Light to it by a Speculum," the Double Reflecting Microscope, the Solar or Camera Obscura Microscope and the Microscope for Opake Objects, and then devotes the remaining chapters to general microscopical technique, concluding with some sound advice:

Beware of determining and declaring your Opinion suddenly on any Object; for Imagination often gets the Start of Judgement, and makes People believe they see Things, which better Observations will convince them could not possibly be seen: therefore assert nothing till after repeated Experiments and Examinations, in all Lights, and in all Positions.

When you employ the Microscope, shake off all Prejudice, nor harbour any favourite Opinions; for, if you do, it is not unlikely Fancy will betray you into Error, and make you think you see what you would wish to see.

Remember, that Truth alone is the Matter you are in Search after; and if you have been mistaken, let no Vanity seduce you to persist in your Mistake.

Part II. of the work (*cf.* Fig. 1) is devoted to an account of microscopical discoveries and to "Pointing out many uncommon Subjects to the Enquiry of the Curious." The material presented is largely gleaned from the works of others, chiefly Leeuwenhoek, Swammerdam, Hooke, Power and Derham—to whose works he gives page references in every instance—but in addition he inserts many observations of his own, some new and some from his papers before the Royal Society, and also intersperses the whole with pertinent remarks in regard to the subject under immediate consideration. For example, in his account of blood:

I believe it will be allowed, that where one Person dies from a Dis-

THE

MICROSCOPE Made Easy:

OR,

I. The *Nature*, *Uſes*, and *Magnifying Powers* of the beſt Kinds of MICROSCOPES *Deſcribed*, *Calculated*, and *Explained*: FOR THE

Inſtruction of ſuch, particularly, as deſire to ſearch into the WONDERS of the *Minute Creation*, tho' they are not acquainted with *Optics*.

Together with

Full Directions how to *prepare*, *apply*, *examine*, and *preſerve* all Sorts of OBJECTS, and proper Cautions to be obſerved in viewing them.

II. An Account of what ſurprizing *Diſcoveries* have been already made by the MICROSCOPE: With uſeful Reflections on them.

AND ALSO

A great Variety of new *Experiments* and *Obſervations*, pointing out many uncommon Subjects for the Examination of the CURIOUS.

By *HENRY BAKER*, Fellow of the *Royal Society*, and Member of the Society of *Antiquaries*, in *London*.

Illuſtrated with COPPER PLATES.

The SECOND EDITION: With an additional *Plate* of the *Solar Microſcope*, and ſome farther Accounts of the POLYPE.

Rerum Natura nuſquam magis quàm in Minimis tota eſt.
PLIN. Nat. Hiſt. Lib. xi. c. 1.

LONDON,
Printed for R. DODSLEY, at *Tully's Head* in *Pall-Mall*, and ſold by M. COOPER, in *Pater-noſter-Row*, and J. CUFF, Optician, in *Fleetſtreet*. 1743.

FIG. 1.

EMPLOYMENT
FOR THE
MICROSCOPE.
In TWO PARTS.

I. An Examination of *Salts* and *Saline Subſtances*, their amazing *Configurations* and *Cryſtals*, as formed under the Eye of the *Obſerver*:

WITH

Plain Directions how to prepare ſuch Subſtances, and preſerve them in conſtant Readineſs for Inſpection; whereby the *Curious* may always be furniſhed with numberleſs Objects hitherto little known.

ALSO

Occaſional Conſiderations on *Gems*, *Poiſons*, the *Vegetation of Metals*, the *Reſuſcitation of Plants*, the *Formation of Amber*, *Corals*, and many other Subjects.

II. An Account of various ANIMALCULES never before deſcribed, and of many other *Microſcopical* DISCOVERIES:

With OBSERVATIONS and REMARKS.

LIKEWISE

A Deſcription of the MICROSCOPE uſed in theſe Experiments, and of a new *Micrometer* ſerving to ſhew the Size of magnified Objects.

Together with

Inſtructions for printing off any *Medal* or *Coin*.

Illuſtrated with Seventeen COPPER PLATES.

By *HENRY BAKER*, Fellow of the *Royal Society*, and Member of the Society of *Antiquaries* of *London*.

Rerum Natura nuſquam magis quàm in Minimis tota eſt.
PLIN. Hiſt. Nat. Lib. XI. cap. 2.

LONDON:
Printed for R. DODSLEY, at *Tully's-Head* in *Pall-mall*: and ſold by M. COOPER in *Pater noſter-Row*; and J. CUFF, Optician in *Fleet-ſtreet*. 1753.

FIG. 2.

order in the containing Vessels, twenty miscarry by some unnatural Alteration in the Fluids that pass through them: and therefore, if we can find what their natural State is, the Means whereby it may be preserved in such State, by what Accidents it may be prejudiced, and how it may be restored, our Pains will be well employed.

In order to obtain this useful Knowledge, it will be necessary to examine the human Blood and other Juices, frequently, with the *Microscope*, in every Condition, and under every Distemper, as well as in a State of Health: by which we shall have ocular Demonstration of its different Appearances in each State, and of the Changes it undergoes; and by Experiments of various Mixtures with it, may possibly discover by what Means it can be altered from one Condition to another. . . .

Would our learned Physicians, who are best able to judge of such Matter, be induced to take this Method into their Practice, it is reasonable to believe, that in a few Years the Causes of Diseases would be better known, and the Art of Healing brought to a much greater Certainty, than it is at present. . . .

Many Distempers might perhaps be cured by an immediate Admission of some Medicine into the Veins, which elude the Power of all that can be taken by the Mouth. For the Stomach, by its Heat, its Action, and a Mixture of its Juices, works such an Alteration in Things before they can be admitted into the Blood, that they are unable to produce the same Effects as if they were received into it simply and unchanged.

In the chapter on the generation of organisms he says that

Nothing seems now more contrary to Reason, than that *Chance* and *Nastiness* should give a Being to Uniformity, Regularity, and Beauty: that two such unlikely Principles should produce, in different Places, Millions of Vegetables of the same Kinds, and alike exactly, even in the most minute Particularities: or, what is yet more amazing, that dead *corrupting Matter*, and blind *uncertain Chance*, should create living Animals. . . . This, however, was the Opinion, not only of the Ignorant and Illiterate, but of the most learned grave Philosophers of preceding Ages; and would probably still have been taught and believed, had not *Microscopes* discovered the Manner how all these Things are generated. . . .

And, again, that

The Growth of Animals and Vegetables seems to be nothing else but a gradual Unfolding and Expansion of their Vessels, by a slow and progressive Insinuation of Fluids adapted to their Diameters; until, being stretched to the utmost Bounds appointed them by Providence at their Formation, they attain their State of Perfection, or, in other Words, arrive at their full Growth

—a view which called forth the verses from *The Universe* which were quoted on an earlier page.

The numerous illustrations which are grouped on 15 copper plates include, for example, good reproductions of Leeuwenhoek's original figure of *Hydra* from the *Philosophical Transactions*, and what is probably the first figure of a *Paramecium*, from an anonymous communication in the same publication.

Concordant with the custom of the time:

Before this Treatise is concluded, it will not perhaps be thought unprofitable to examine some of the finest and most exquisite Performances of human Art, and compare them with the Productions of Nature; as such a Comparison must tend towards humbling the Self-conceit and Pride of Man, by giving him a more reasonable and modest Opinion of himself; and at the same time may in some Degree conduce towards improving his imperfect Conceptions of the SUPREME CREATOR. . . .

The Use of the *Microscope* will naturally lead a thinking Mind to a Consideration of *Matter*, as fashioned into different Figures and Sizes, whether Animate or Inanimate: it will raise our Reflections from a Mite to a Whale, from a Grain of Sand to the Globe whereon we live; thence to the Sun and Planets; and, perhaps, onwards still to the fixt Stars and the revolving Orbs they enlighten, where we shall be lost amongst Suns and Worlds in the Immensity and Magnificence of Nature.

Although the proportion of Baker's own observations is relatively very small, the work is far from being merely an excellent compilation, as it is permeated throughout with the spirit of a man who is a constant, enthusiastic devotee of microscopic study and who is acquainted first hand with a large part of the material he is presenting.

The success of "The Microscope Made Easy" led Baker to publish ten years later his "Employment for the Microscope," which is practically a supplement to the second part of his first book—and after 1753 the two works were usually sold together under the title "Baker on the Microscope." This second volume is largely a compilation of Baker's own studies of animalcules from various sources and here we find a Suctorian figured for the first time, apparently *Podophrya quadripartita*, as well as a number of other hitherto undescribed organisms. Baker, like Joblot, makes an attempt to give more or less appropriate names to the various organisms which he describes but he does not apply a binomial nomenclature or classify them—Dr. John Hill, during the previous year, being the first to give animalcules definite Latin names (*e. g., Paramecium*) and to arrange them in groups, under the influence of the rapid advances in taxonomy at the time.

Although Baker's studies on microscopic organisms have been emphasized above, apparently he himself and the Royal Society were more pleased with his studies, presented at length in this volume, which he had been making

for above ten Years past, on a great variety of Saline Bodies, Mineral, Vegetable and Animal, as well as many other Substances, both simple and compound, whose Parts can be dissolved in Fluids, after a Method which has never hitherto been described by any Author, or practised before myself by any body that I have heard of. And tho' I have found their original Particles undiscoverable by any Microscope, the Time I hope has not been wholly misemployed; since I have been enabled, by the help of that

Instrument, to behold the amazing Order and Regularity, wherewith, after being separated by Dissolution, they come together and re-unite under the Eye, when put in Action by certain Degrees of Heat, in Configurations appropriated to each of them respectively, and with a Constancy that is surprising.[3]

The Experiments here described, and which the Reader is instructed to make, must I think generally entertain; but merely to entertain, is, I hope, the least of their Worth. They may possibly lead to the Knowledge of what passes in the Formation of Gems, and the most beautiful mineral Productions: And as every new Discovery is an Encouragement to farther Disquisition, the Hints here given may perhaps set abler Heads at Work to improve Art on the Principles of Nature. Examinations by the Microscope, in the Manner here directed, may likewise be employed to ascertain the Truth and Purity of many simple Substances and Compositions made use of in Medicine, and detect Fraud and Imposition.[4]

For this work Baker received the Copley Medal of the Royal Society for 1774 which was awarded "to whomsoever of the members shall be deemed to have produced the most extraordinary Discovery during the whole year."

The volume concludes with a chapter on "Miscellaneous Observations" which includes a section on the microscopes of Leeuwenhoek.

Though Mr. Leeuwenhoek's Microscopes are much talked of, very few People are acquainted with their Structure and Apparatus, no Figure of them that I remember having ever been made publick: 'tis therefore hoped the Curious will be pleased to see a Drawing of them, taken with great Exactness from those in the Repository of the *Royal Society*. . . .

Baker was apparently a congenial spirit and "Societarian," being for nearly thirty years one of the most active Fellows and frequent members of the Council of the Royal Society, a Fellow of the Antiquarian Society of London, and a founder and secretary of the Society for the Encouragement of Arts, Manufactures and Commerce. Martin Folkes, during his eleven-year presidency of the Royal Society, was on terms of considerable intimacy with Baker, being one of a small group of the Fellows who met now and then at Baker's home to consider matters philosophical. Folkes apparently had great confidence in Baker's skill with the microscope and frequently asked him to verify observations communicated to the Royal Society through the president.

It was in this capacity, for example, that Baker made his observations on the origin of "Eels in blighted wheat" (which Needham had communicated in his "New Microscopical Discoveries," London, 1745, and later advanced as support of the

[3] "Employment for the Microscope," Chapter I.
[4] *Ibid.*, Dedication.

An Attempt towards a

NATURAL HISTORY OF THE POLYPE:

In A LETTER To

Martin Folkes, *Eſq*;

PRESIDENT of the *Royal Society*.

DESCRIBING

Their different Species; the Places where to ſeek and how to find them; their wonderful Production and Increaſe; the Form, Structure and Uſe of their ſeveral Parts; and the Manner they catch their Prey:

With an Account of their DISEASES and CURES; of their amazing REPRODUCTION after being cut in Pieces, (as firſt diſcovered by Mr. TREMBLEY, at the *Hague*;) of the beſt Methods to perform that Operation, and of the Time requiſite to perfect the ſeveral Parts after being divided: And

Alſo full DIRECTIONS how to feed, clean, manage and preſerve them at all Seaſons of the Year.

Likewiſe a COURSE of real EXPERIMENTS, performed by cutting theſe Creatures in every Way that can be eaſily contrived: ſhewing the daily Progreſs of each Part towards becoming a perfect POLYPE.

The Whole explained every where by great Numbers of proper Figures, and intermixt throughout with Variety of OBSERVATIONS and EXPERIMENTS.

By *HENRY BAKER*, Fellow of the *Royal Society*, and Member of the Society of *Antiquaries*, in *London*.

Rerum Natura nuſquam magis quàm in Minimis tota eſt.
PLIN. Nat. Hiſt. Lib. xi. c. 2.

LONDON:
Printed for R. DODSLEY, at *Tully's Head* in *Pall-Mall*, and ſold by M. COOPER in *Pater-noſter-Row*, and J. CUFF, Optician, in *Fleet-ſtreet*. 1743.

(Price bound Four Shillings.

FIG. 3.

well-known "Buffon-Needham Theory") as well as his study of *Hydra* which he published in a volume of 222 pages under the title of "An Attempt towards a Natural History of the Polype: In a Letter to Martin Folkes, Esq; President of the Royal Society," London, 1743 (*cf.* Fig. 3).

That curious Observer of Nature, Mr. LEEUWENHOEK, first took notice of this Animal, and the uncommon Way its young ones are produced, in the Year 1703 . . . but its more amazing Properties were reserved for the Inquisitive and happy Genius of Mr. TREMBLEY to discover, in the Year 1739 . . . observing it in some Respects to bear the Resemblance of a Plant, and in others of an Animal, he resolved, by cutting it in pieces, to satisfy himself, whether of the two it really was; and found, by this Trial, that, after a few Days, each Piece became a perfect Body, of the same Form exactly as *That* of which it had been only a Part: which Appearance would have determin'd him to conclude it to be a Vegetable, had he not discovered in it at the same time, a frequent Change of Figure, a Motion from place to place, a greedy and voracious Appetite, and a singular Dexterity in catching, mastering and devouring Insects and Worms. . . .

In consequence of these Discoveries, he, ever since, has been making a Variety of such Experiments as none but his own fertile Invention would, probably, have contrived. These Experiments were performed in Sight of many of the Curious. . . . Some of these Creatures were likewise sent both to Mons. REAUMUR and YOU, lest any Difficulty of finding them, might prevent, discourage, or delay making the same Trials in *France*, or *England*, as himself had done at the *Hague*.[5]

When Accounts of the extraordinary Properties of this Creature were communicated to you . . . it was never expected we should rest contented with their Accounts without making Experiments ourselves: *Nullius in Verba* being the wise Motto and establish'd Maxim of the ROYAL SOCIETY. But in respect to the Reputation of the ROYAL SOCIETY as well as to the Gentlemen who communicated these Discoveries, it became incumbent on us, as soon as they had sent the Insects over hither, to put them to a severe but speedy Trial, and from the Issue of our own Experience, either convince the World that these Gentlemen had been mistaken, or give our Testimony that what they affirm is true. This, SIR, was your opinion. . . .[6]

YOU was, likewise, so obliging to favour me with three of your *Polypes*, very soon after their Arrival, with Intent that I should put them to the severest Test; and, to encourage and assist me in so doing, have frequently honoured me with your Company, and been yourself a Witness of my Proceedings.

With these three *Polypes* I began my Experiments. . . . And I have gone on till this very Day repeating most of them several Times over, without finding any considerable Difference, but that of a much quicker Growth and Separation of the Parts cut to Pieces as the Weather became warmer. . . . Though it may not be improper to remark, that what by Divisions, Subdivisions, and the Creature's natural Increase, several hundreds have been produced by my first three, between *March* the twenty fifth, and the present fourth Day of *August*.

[5] "Natural History of the Polype," pp. 4–5.

[6] *Ibid.*, p. 201.

These, however, were not all the Polype I have had under my daily Care and Inspection: for . . . Mr. ELLICOTT, F.R.S. gave me six *English* Ones, and . . . seven or eight green Ones, . . . which have also increased considerably. And, in *July* last, you favoured me farther with some of the longarm'd Sort, just then arirved from Mons. TREMBLEY.

You, SIR, who know my Way of thinking, will not I am persuaded so far mistake me, as to imagine I am attempting, by this Essay, to vie either with yourself, or Mr. TREMBLEY; but it may not be improper to assure that Gentleman and the World, who are not so well acquainted with me, that I am as far from, as unequal to, such a Design; and that my real and only Motive to the many Experiments I have made, to the Care I have taken in propagating these Creatures, to the Readiness wherewith I have sent Numbers of them to *Oxford* and *Cambridge*, and dispersed them, as much as I have been able, amongst the Curious, and to this present Undertaking, has been to vindicate the Truth: which suffers sometimes for want of proper Means to prove it: and to display before Mankind, a new Instance of the amazing Power of the Creator.[7]

Thus the first book devoted to regeneration in animals appeared in England in 1743 and in a French translation in Paris in 1744, the same year that Trembley's famous "Mémoires pour servir à l'histoire d'un genre de Polypes d'eau douce" was issued at Leyden.

In view of the fact that Baker's work is not discussed in any, and the title of his book appears in the bibliography of only one of the recent volumes on regeneration, as a matter of record it seems worth while to give his list of experiments:

Experiment I. Cutting off a Polype's Head; II. Cutting a Polype in two Pieces, transversly; III. A Polype cut in three Pieces transversly; IV. Cutting the Head of a Polype in four Pieces; V. Cutting a Polype in two Parts, lengthways; VI. Cutting a young Polype in two Pieces whilst still hanging to its Parent; VII. Cutting a Polype lengthways through the Body, without dividing the Head; VIII. A Repetition of the foregoing Experiment, with different Success; IX. Cutting a Polype in two Places through the Head and Body, without dividing the Tail; X. Cutting off half a Polype's Tail; XI. Cutting a Polype transversely, not quite through; XII. Cutting a Polype obliquely not quite through; XIII. Slitting a Polype open, and cutting off the End of its Tail; XIV. Cutting a Polype with four young Ones hanging to it; XV. Quartering a Polype; XVI. Cutting a Polype in three Pieces the long way; XVII. An Attempt to turn a Polype, and the Event; XVIII. Turning a Polype inside out; XIX. An Attempt to make the divided Parts of different Polypes unite; XX. A speedy Reproduction of a new Head; XXI. A young Polype becoming its Parent's Head; XXII. A cut Polype producing a young One, but not repairing itself.

In regard to Experiment XVIII., a repetition of Trembley's famous one in which he believed that he had permanently turned a Polype inside out, Baker says:

Though I made several Trials before and since, I could never succeed

[7] *Ibid.*, pp. 6–10.

in turning *Polypes*, so well as in the above Experiment: which I impute to my Want of the Means Mr. TREMBLEY uses, as well as the Dexterity whereof he is Master: whose Account of his having turned many, and their living, thriving, and producing young Ones in that inverted State, I don't in the least doubt the Truth of. And when that Gentleman pleases to publish his own Method, which I should think myself unworthy of knowing if I endeavoured to take any of the Honour of it from him, most reasonable People, I believe, will be convinced.

The following extracts are from Baker's concluding remarks:

Having now, SIR, laid before you the most remarkable of my Experiments, in relation to the cutting *Polypes* asunder, and the Re-production of new Parts to make each Piece a perfect *Polype*; I shall entreat your Patience a little longer, whilst I add a few occasional Reflections. . . .

Though real Facts are incontestable Arguments, and no Reasoning seems necessary after so many repeated Experiments, there are certain Prepossessions, Prejudices and Humours among Mankind (arising from early imbibed Theories or Systems, according to which they have accustomed themselves to judge of Things) that make People sometimes disbelieve even what they see, are stronger than Reason, and will hardly be conquer'd even by the plainest Facts.

Hence it is that some have objected to the Reality of the *Polype's* being a living Creature, notwithstanding its moving from Place to Place, seizing its Prey, eating, digesting, and other Animal Functions: because its other Properties happen to be unsuitable to their Hypothesis of Life in general.

If the Animal Soul or Life, say they, be one indivisible Essence, all in all, and all in every Part, how comes it, in this Creature, to endure being divided forty or fifty Times, and still continue to exist and flourish?

Again: If animal Identity, say they, consists in Consciousness; and if every living Creature is sensible of Pleasure and Pain, or in other Words has a Consciousness, which most think a reasonable Supposition; when the *Polype* is divided into several Parts, all soon becoming perfect *Polypes*, where shall we find the Identity of the original *Polype*?

These Queries, I must acknowledge, I am wholly uncapable of resolving: but let those who tye themselves down to such Theories seriously consider, whether they believe themselves so perfectly acquainted with every living Creature God has made, and with all the Modes and Circumstances of the Life of each, as to be certain their Theories comprehend them all. 'Tis, methinks, a little presuming to restrain the Operations of Nature, or imagine that God has done nothing but according to certain Rules well known to us.

It is one great Part of Wisdom to know what we have Abilities for, and what Things are beyond our Power; that we may apply to the former, and avoid perplexing ourselves about the latter. How much valueable Time has been thrown away in framing whimsical unsatisfactory Schemes to account for the Operations of Nature, which might have furnished a great deal of profitable Knowledge, if spent in real Experiments on those self-same natural Operations?

When a Twig is cut off, and by planting in the Earth becomes a Tree of the Kind whereof it was a Part, can we account for its becoming so, any thing better than we can for the like Effect in a *Polype*? . . . The

whole Difference is, we have known the One a long while, and the other is a late Discovery, which has not yet been noticed in our System of Animal Life. . . .

'Tis no great Wonder that Discoveries contrary to old and established Opinions should not at first be credited; but then, neither should they be absolutely rejected till Experiment has been made whether they are true or false.

Those that know the most, are most sensible how little they know in comparison of what is yet unknown, and therefore consider Things with Modesty and Candour: but Ignorance cries out at once, it cannot be:—inconsiderately measuring the Powers of Nature by the scanty Compass of its own Experience, and more ready to reject the Truth than take the Pains to find it out.—A truly wise Man is so fully sensible how little he knows, and what Things he once was ignorant of, which he is now acquainted with, that he is far enough from supposing his own Judgment a Standard of the Reality of Things.

Trembley's and Baker's demonstrations of the potentialities of the polype, reflected by Linnæus naming it *Hydra,* and Hill, *Biota,* on account of the "strong principle of life with which every part is endued," created considerable excitement in scientific, philosophical and literary circles. They apparently had forgotten that Aristotle observed that there are animals as well as plants which propagate themselves by shoots; and on cutting one of these animals, the pieces which before comprised altogether but one animal become suddenly so many distinct individuals. And further that the soul in animals is in effect but one, though "multiplied in its powers as in plants." Or that St. Augustine relates in his "De Quantitate Animæ" that a friend in his presence cut a 'polype' in two, and immediately the two parts betook themselves to flight in opposite directions![8]

Henry Baker's original observations undoubtedly do not entitle him to a place among the leading pioneers with the microscope—for most of his observations were made apparently at random without any particular purpose in view and none of his discoveries is of great significance—while some of them are not discoveries at all, as Hill,[9] in his animadversions on the Royal Society, takes especial pleasure in pointing out. But Baker's books, appearing at a time when the effects of the first glimpses into the "world of the infinitely little" were slowly permeating into general culture, had a considerable influence on the popularization of microscopic work and the general recognition of its practical value, as well as in stimulating microscopic research.

[8] Adams, "Essays on the Microscope," 2d edition, London, 1798.

[9] *Review of the Royal Society,* London, 1751.

"Baker on the Microscope" was something new—a product of the time—though, in a way, a descendant, with modifications, of Joblot's work on animalcules and microscopes[10] first published during the Leeuwenhoek period, and later reprinted with but slight change in 1754, when Baker's works were among the "best sellers." "Baker" was the humble forerunner within the limits of less than 800 octavo pages of our present-day manuals on bacteriology, protozoology and microbiology in general as well as of manuals on the microscope. Its success soon brought many competitors into the field, both in England and on the Continent—competitors such as the works by Adams which increased in bulk with each edition—but none of them approached it in originality of treatment, quaintness of expression, philosophical insight or the contagious enthusiasm of its author for things that are small.

"Baker on the Polype," the first volume ever devoted to regeneration in animals, gradually sank into oblivion on account of Trembley's classic memoir, but not without having exerted a considerable influence in England in stimulating experiments and speculations on life phenomena as "exhibited by that wonderful fresh-water insect the Polype."

It has been said of Mr. Baker, that he was a Philosopher in little things. If it was intended by this language to lessen his reputation, there is no propriety in the stricture. . . . He was an intelligent, upright, benevolent man much respected by those who knew him best. His friends were the friends of Science and Virtue: and it will always be remembered by his contemporaries, that no one was more ready than himself to assist those with whom he was conversant, in their various researches and endeavors for the advancement of knowledge, and the benefit of Society.[11]

[10] "Descriptions et usages de plusieurs nouveaux microscopes, tant simples que composez; avec de nouvelles observations faites sur une multitude innombrable d'insectes, & d'autres animaux de diverses especes, qui naissent dans des liqueurs préparées, & dans celles que ne le sont point." Paris, 1718.

[11] Biographia Britanica, 2d edition, London, 1778.

ON THE HISTORY OF THE PROBLEM OF SEPARATING A NUMBER INTO ITS PRIME FACTORS

By Professor D. N. LEHMER

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PERHAPS no other branch of mathematics offers to the non-mathematician so many inviting problems as the theory of numbers. The tools it employs are the simplest, and the methods of operation are familiar to every school-boy. It abounds in problems apparently of the greatest simplicity and really of such subtle make-up that they have baffled the efforts of the greatest mathematicians for centuries. There are many properties of numbers which we use daily, and which most of us are willing to take on experimental evidence, which would puzzle the untrained man to account for. What clerk has not used the method of "casting out the nines" to prove his computations—and how many clerks could give a valid reason for the check, and tell what are its limitations, or state the general law of which this is a special case?

Every carpenter has made use of the right triangle whose sides are 3, 4 and 5 with which to lay off a right angle. No doubt this was the practical method of constructing a right angle in the days of the pyramid builders. He would be a stupid carpenter who would never inquire if other triangles of that sort were not obtainable. He might easily find that others were to be had by multiplying the sides of this triangle by any number, but the question would still confront him as to the existence of other such triangles with sides having no common divisor. By experiment, which enters more into the investigation of problems of this sort than many imagine, he would perhaps hit upon the triangle 5, 12, 13, and then upon the triangle 8, 15, 17. He might then, for his own amusement, undertake to make a list of these triangles, arranging them in order according to the magnitude of the largest side. He would be rewarded first of all by the interesting discovery that sometimes two different triangles may have the same hypothenuse! such as 39, 52, 65 and 25, 60, 65. If he were of a statistical turn of mind he might discover that the number of triangles in his list increased with remarkable regularity with the magnitude of

the largest side. The number of triangles with largest side less than N is roughly proportioned to N. At this point in his career he may apply for help to some well-equipped specialist in the theory of numbers, and the result may be that a good carpenter is spoiled to make a trifling mathematician. One such experimenter, to my knowledge, pushed the investigation through till he found that the number of triangles with sides not greater than N is approximately $N/2\pi$ where π is the number 3.1415926 . . . which represents the ratio of the circumference of a circle to its diameter.

But of all the problems that lure the man of the street into the halls of useless but fascinating research none seems to appeal with more potent call than the problem of separating a given number into its prime factors. It is so easy to multiply two numbers together, and so hard to find them again when they have been welded into one! A multiplying machine will furnish the product of two eight-digit numbers in a few minutes. With all the resources of the theory of numbers at my disposal, I have spent I am ashamed to say how many hours in trying to determine whether the number 403,978,495,031 is a prime or not, and the question is still open. Why should I be interested, you ask, in such a problem? The answer to that question is that experimental work in another field is stopped till this vexing matter is settled. The problem of finding the factors of a given number is not only interesting in itself, but is vital for the investigator in many other researches, particularly in the theory of groups.

Perhaps some notion of the immense antiquity of this problem may be gained by observing that it is a problem that freguently suggests itself to children of ten or twelve years of age. When the progress of civilization in any tribe was such that the most thoughtful members were capable of the intellectual effort of a modern boy of fifteen the problem might likely arise. It might easily have attracted the attention of the cave man that six pebbles could be arranged in two ways; ..... and :::, while only one such arrangement could be found for five or seven pebbles. The discovery of the three ways of grouping twelve pebbles must have been as exciting and mystifying to the original researcher as the discovery of the first magic square. No doubt the number twelve gained considerable respect from this mystic property. The number six later enjoyed great prestige, because it was found that the sum of its divisors 1, 2 and 3 is equal to six! Pythagoras is said to have venerated the number 6 on account of the "integrity of its parts and the

agreement existing in it," calling it marriage and health and beauty! According to the early Christians, God created the earth in six days rather than in one because of the perfection of the number six. The entire human race sprang from the eight souls in Noah's Ark, and, as 8 is not so perfect as 6, we have been living under a disadvantage ever since!

Little is known of the assaults of the ancients on our problem. Their clumsy notation would have lent them little aid in their fight. It was a learned man that could perform a simple division even as late as the thirteenth century. Men like Archimedes were needed to get an approximation to a square root. Practical computation was done on the fingers or on the abacus, and perhaps the notation was of little more use than as a means of recording results. Nevertheless, it would be wrong to assume that previous to the invention of the modern method of denoting numbers mankind was not in possession of some of the most beautiful theorems concerning the properties of numbers. Thus Euclid gives a proof of the infinite number of primes, a proof which is found in almost every treatise on numbers to this day; and his process of finding the greatest common divisor, and his formula for perfect numbers are familiar to every student of this subject.

The first practical contribution to the problem of finding the factors of a number comes from another Greek, Eratosthenes, who lived some time in the second or third century B.C. He seems to have been a man of the greatest versatility, and has left his imprint on many different pages of science. He was librarian at the university of Alexandria, and was noted for his athletic achievements as well as for his literary interests. He devised the calendar in which every fourth year is 366 days long. He measured the length of a degree on the earth's surface and got a good approximation for the radius of the earth. In connection with our problem he invented the so-called "sieve" method which is the basis of construction of all the great factor-tables constructed since his day.

The sieve of Eratosthenes is constructed on the following observation: Every other number after 2 is divisible by 2; every third after 3 is divisible by 3; every fifth after 5 is divisible by 5 and so on. If then we write down the successive numbers in a row and erase every other number beginning with 4, and every third number beginning with 9, and every fifth number beginning with 25; and every seventh number beginning with 49, and so on, we shall have in the remaining numbers a list of successive primes. If instead of erasing the num-

bers we write over every other number beginning with 4 the factor 2, over every third number beginning with 9 the factor 3 we shall have for each number its decomposition into prime factors. The process requires no computation, and may be carried out by measurement alone.

Now the writing of a million numbers in a row turns out to be a somewhat tedious undertaking. Moreover, we are not much interested in finding the factors of the even numbers nor of the multiples of 5. If now we group the numbers in lines of ten thus

1, 2, 3, 4, 5, 6, 7, 8, 9, 10
11, 12, 13, 14, 15, 16, 17, 18, 19, 20
21, 22, 23, 24, 25, 26, 27, 28, 29, 30

we see that all the even numbers lie in the same columns and that the same is true of the multiples of 5. We then omit these columns altogether, thus cutting out sixty per cent. of the numbers in our list. This method of shortening the table of factors seems not to have been used till about the middle of the seventeenth century, when Rahn,[1] or Rhonius, gave such a table extending to 24,000, shortly afterwards extended to 100,000 by Thomas Brancker.[2] The tables preceding Rahn's tables were of a very insignificant sort. Thus Leonardo Pisano[3] in 1202 gave a list of the primes from 11 to 97, and the factors of the composite numbers from 12 to 100. Cataldi[4] in 1603 gave a table extending to 800 and Van Schooten[5] (1657) gave a list of primes to 9979.

It was later discovered that the multiples of 3 could be omitted from the table without very great complication. If we group our list of numbers in lines of thirty we see that the multiples of 2, 3 and 5 all appear in certain columns. Omitting those columns, our list of numbers appears thus:

1, 7, 11, 13, 17, 19, 23, 29
31, 37, 41, 43, 47, 49, 53, 59
61, 67, 71, 73, 77, 79, 83, 89

With the table arranged in this way it is easy to show that if a factor p appears in any place it will also appear in that same column p lines farther down. Eratosthenes's sieve method may then be applied to each column, or better by means of a

[1] Rahn, "Algebra," Zurich, 1659.

[2] Brancker, "An Introduction to Algebra," translated out of the High-Dutch [of Rahn's "Algebra"] into English by Thomas Brancker, 1668.

[3] Pisano, "Il Liber Abici di L. Pisano," 1202, revised 1228.

[4] Cataldi, "Trattato de' numeri perfetti," Bologna, 1603.

[5] van Schooten, "Exercitat. Math.," Leiden, 1657.

stencil to all the columns at once, to find the multiples of p. A table in which the multiples of 2, 3 and 5 were omitted was first published in 1728 by Poetius.[6] The invention of the stencil method is to be credited to C. F. Hindenburg,[7] 1776. That same year was published Felkel's[8] table in which the multiples of 2, 3 and 5 were omitted, the extent of the table being 408,000. Felkel made use of the device of designating the numbers by means of letters for the sake of saving space. The manuscript extended to two millions, but the sale was so meager that the entire edition was made into cartridges to use against the Turk. Only a few copies were saved.

In the early nineteenth century, responding to the urgent appeals of men like Gauss and others who were interested in verifying certain curious laws just discovered relating to the distribution of primes, there appeared the great table of Chernac[9] (1811) giving all the prime factors of all numbers not divisible by 2, 3 or 5 up to 1,020,000 containing 1,020 pages. The bulk of a factor table becomes a serious matter when a limit of several million is contemplated. It occurred to Burckhardt[10] that it is sufficient to know the smallest divisor, as the others may be obtained from the quotient. Burckhardt published such a table of the first three millions. Tables modeled after Burckhardt's were afterward published for the 4th, 5th and 6th million by Glaisher,[11] and for the 7th, 8th and 9th, by Dase.[12] The factor tables computed by myself[13] and published by the Carnegie Institution of Washington omit the multiples of 2, 3, 5 and 7 and carry the work up to the limit 10,000,000 (1909). A list of primes based on this factor table was published in 1914.

It should be stated that manuscript tables of factors were computed by a Bohemian named Kulik[14] up to the extraordinary

[6] Poetius, "Anleitung zu der Arith. Wissenschaft vermittelst einer parallel Algebra," 1728.

[7] Hindenberg, "Beschreibung einer ganz neuen Art," Leipzig, 1776.

[8] Felkel, "Tabula omnium factorum simplicium numerorum," 1776.

[9] Chernac, "Cribrum Arithmeticum," 1811.

[10] Burckhardt, "Tables des diviseurs," Paris, 1817, 1814, 1818 (for the respective three millions).

[11] Glaisher, "Factor Tables for the Fourth, Fifth and Sixth Millions," London, 1879, 1880, 1883.

[12] Dase, "Factoren-Tafeln für alle Zahlen der siebenten (1862) der achten (1863) der neunten (1865) Million," Hamburg.

[13] Lehmer, "Factor Table for the First Ten Millions," Carnegie Institution of Washington, 1909.

[14] Kulik. An account of Kulik's table will be found in the introduction to my list of primes. Carnegie Institution of Washington, 1914.

limit of 100 million! They were never published, and are at present, with the exception of one volume which has disappeared, in the library of the Royal Academy at Vienna. The tenth million of this colossal work I examined with great care in comparing it with my own computations and found some 226 errors in this one million. The great work is not accurate enough to warrant publication, but is of the greatest value for purposes of checking. He also represents the prime factors by means of letters, which makes it a little difficult to compare his table with others.

So much for factor-tables and lists of primes. We are still fairly helpless in the presence of a number that exceeds the limit of our tables, but there are certain schemes which avail to shorten the labor of decomposing a number into its factors which are of considerable service, particularly for numbers of certain kinds.

In 1643 Fermat[15] wrote to his friend Mersenne concerning the number 100,895,598,169: "You ask me whether this number is prime or not, and for a method for finding in one day's time whether it is prime or composite. I reply that it is composite and is the product of 898,423 and 112,303." Now this number happens to be associated with certain numbers of the form $2^n - 1$, the factors of which belong, as Fermat was the first to discover, to certain particular arithmetical progressions. If n is prime the factors of $2^n - 1$ are all equal to one plus a multiple of n. Naturally this wonderful theorem relieves one of the necessity of trying as divisors the greater part of the primes less than the square root of the number. Thus the number $2^{11} - 1 = 2047$ can have factors of the form $22n + 1$, so that the only factors we need try are 23 and 45, and the last being composite is also ruled out. By trial 23 is found to be a factor and $2047 = 23 \times 89$. This discovery of Fermat's has delivered into our hands our largest known primes. The largest one known at the present time is, I believe, $2^{127} - 1$, a number of 39 digits examined by Lucas in 1877.

The great Fermat[16] also invented a method of finding factors when nothing is known of the form of the factors which is very effective when the two factors do not differ very greatly from each other. If a square number can be found which when added to the given number produces a square then the given number is at once reduced to the difference of two squares and is the product of the sum and difference of two numbers. Fer-

[15] Fermat, "Œuvres," Tome 2, p. 255.
[16] Fermat, "Œuvres," Tome 2, p. 257.

mat gives the example 2,027,651,281, which he finds by a few trials to be the difference of the two squares 45041^2 and 1020^2. But the difference of these two squares is equal to the product of their sum 46061 by their difference 44021. Fermat was in possession of devices for shortening the labor of finding the two squares, but even with every such device and the help of computing machines, which adapt themselves very well to this method, the process may lead one an interminable chase in finding the factors of some numbers.

A more effective method depends on the theory of quadratic residues, the underlying principles of which may be made clear in a few words. If a number x can be found such that $x^2 - D$ is divisible by a number m then D is said to be a *quadratic residue* of m. D and m are supposed prime to each other. Such a number x is not always obtainable, and if none is to be found D is said to be a *quadratic non-residue* of m. From the definition it follows that if D is a quadratic residue of m it is a quadratic residue of every factor of m, for surely if an x exists such that $x^2 - 1$ is divisible by m then for that same value of x we shall have $x^2 - D$ divisible by every factor of m. The importance of this simple remark arises when we find that the numbers m which have a given D for quadratic residue all fall into certain arithmetical progressions. Thus those numbers which have 2 for a quadratic residue are all multiples of eight plus or minus unity. Those which have 3 for a quadratic residue are all multiples of twelve plus or minus unity, etc. If then it is known by any means that 2 and 3 are residues of a number we know that not only the number itself, but every odd factor of it, belongs to both of these series of numbers, and consequently belongs to the series 1, 25, 49, 73, 97, . . . or to the series 23, 47, 71, 95, . . . or, as we say, is of the form $24n + 1$. This knowledge enables us then to omit from our list of trial divisors all primes which do not fall in these series and the process of searching for factors is notably shortened.

It will at once be observed that the difficulty has only been shifted from one corner to another, and we are still confronted with the serious problem how to obtain quadratic residues small enough to be of service in this connection, for it should be observed that for larger quadratic residues the number of series is increased. Various devices have been invented for finding directly suitable quadratic residues, the best of which seems to be a by-product of the theory of continued fractions. Another is based on the theory of binary quadratic forms. All of these

methods have been in use for over a century, and are to be found in the works of Euler[17] and Legendre.[18] Where nothing is known of the form of the factors of the number these methods are perhaps the most powerful in our possession.

As the matter stands, then, we are complete masters of the situation for numbers up to ten millions, having reliable tables extending so far. There are photographic copies in this country of Kulik's table for the eleventh million, of which I have one. His second volume running from 12,642,600 to 22,852,800 is lost. The remaining volumes carry the table up to a limit of 100,330,201. In spite of their inaccuracy they are of the greatest value for comparison. For numbers beyond the limits of the available tables modern methods can be applied with fair hopes of success up to a limit, perhaps, of a billion. Beyond that limit, except for numbers of special form, the task of finding factors may well daunt the most intrepid of computers. The problem will always confront the human race. The invention of new methods may push off the limits of the unknown a little farther, just as the invention of a new astronomical instrument may push off a little the boundaries of the physical universe; but the unknown regions are infinite, and if we could come back a thousand years from now we should no doubt find workers in the theory of numbers announcing in the journals new schemes and new processes for the resolution of a given number into its factors.[19]

[17] Euler, "Nova Acta Petrop," 13, 1795–6.

[18] Legendre, "Theorie Des Nombres," 1798, pp. 313–320. A more complete bibliography will be found in the forthcoming "History of the Theory of Numbers," by L. E. Dickson, from which many of the above references are obtained.

[19] Since writing the above I have found the number 403,978,495,031 is equal to $6{,}151 \times 65{,}676{,}881$, both factors being primes. By expanding the square root of the number in a continued fraction it was found that the following numbers were quadratic residues: 2, 5, 7, -13, -17, 23, -29, 31, 43. This knowledge enabled me to reduce the number of trials to fifty-five. If the number had been a prime I should have had some seventy-five trials to make instead of over fifty-one thousand to determine the fact. The number is the denominator of the twenty-ninth convergent to the base of Naperian logarithms when that base is expanded in a regular continued fraction.

PLANT PATHOLOGY TO-DAY

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THAT plant pathology in America has passed through its pioneer period and is now entering on a period of increased activity, broader scope, and greater usefulness is evident to all who have followed its recent development. In the words of Galloway,[1] who was one of the early workers and who has been closely associated with the growth of phytopathology in this country for the past thirty years, "For nearly a quarter of a century the study of plant pathology in this country was without very broad or definite aim or object." The condition described was due largely to the fact that the development of the subject in this country has been largely determined by economic and political conditions and demands rather than by any well-conceived and directed plans of the plant pathologists.

Plant pathology as a special subject of study and investigation in this country was taken up chiefly by the United States Department of Agriculture and the state experiment stations. At that time the work was necessarily restricted, the available knowledge of the subject small, the demands for immediate practical results large and the workers few. Notwithstanding these restrictions and the imperative demands for immediate results, many important discoveries of fundamental value were made, for example, the discovery that bacteria[2] caused plant disease and that the bacteria may be carried by insects.[3]

This was distinctively the utilitarian period in the development of the subject. During this economic or utilitarian period much time was necessarily devoted to spraying experiments, describing and cataloging pathogens and other fungi, and laying the foundation for more thorough and fundamental re-

[1] Galloway, Beverly T., "Some of the Broader Phytopathological Problems in their Relation to Foreign Seed and Plant Introduction," *Phytopathology*, 8: 87–97, 1918.

[2] Burrill, T. J., "Report on Botany and Vegetable Physiology—Pear-blight," *Trans. Ill. State Hort. Soc.*, N. S., 11: 114, 1877, and 12: 80, 1878; Arthur, J. C., "Proof that Bacteria are the Direct Cause of the Disease known as Pear Blight," *Bot. Gaz.*, 10: 343–345, 1885.

[3] Waite, M. B., "Results from Recent Investigations in Pear Blight," *Bot. Gaz.*, 16: 259, 1891.

searches. The demands for immediate practical results and the application of pathological knowledge have continually tended to exceed the output of the necessary fundamental research and exact knowledge and have tended to encourage superficial work and the drawing of conclusions from too little evidence. The great demand for men and for practical applications of the science has also tended to encourage hasty preparation and insufficient training. The notable achievements in the field during the period have been due to the importance of the problems attacked, and to the skill of the individual investigators rather than to definite and coordinated plans of work. So striking indeed were the discoveries of the earlier pathological investigators in this country, and so important their results in the control of plant diseases that recent workers have tended too generally to follow the lines laid down by their predecessors, lines which had proven profitable in the past and give promise of results of more or less importance in the future.

In part then as a result of notable successes in certain directions and in part for economic and political reasons, the plant pathologist has had a rather restricted field of activity, not only as to the area in which he worked and as to the host plants investigated, but in particular as to methods of work and as to the aim and subject-matter of his studies.

The geographic limitations of the work were particularly unfortunate in that they were not the natural limitations of crop or climate, but the artificial ones of state and national boundaries. There was also a lack of cooperation and coordination of work. Pathologists in adjacent states investigated related problems with too little interchange of views. Foreign visits and studies have been too few and too short and have not been followed by sufficient work at home, as is indicated by the fact that there has been but little publication on the work of American pathologists in foreign countries. In this hemisphere tropical pathology has been, when the agricultural importance of the regions is considered, all but neglected.

It is natural and desirable that the study of plant pathology should be centered on plants of great economic importance. Scientifically and in the long run economically it would be of great value if the diseases of wild plants could be thoroughly investigated, especially those closely related to important cultivated plants.

Equally restricted have been the lines of attack followed when a new disease was to be studied or a familiar one attacked in a new area. To find a plant or plant part with evident ab-

normalities, to describe the condition, to isolate an organism from the affected parts, to grow this organism in pure culture and describe it, to produce an abnormal condition by inoculation with this organism and to prevent or reduce the abundance of the disease by spraying, these things were usually considered sufficient.

The field of the plant pathologist has been largely limited to the production phases of the important crops he has chosen for his work. By seed treatment and by spraying, by crop rotation and soil treatment, he has assisted the farmer in producing a crop and there he has stopped. The student of apple diseases, for instance, has taken his results and ceased his work when the crop was harvested, leaving the study of the important and far-reaching changes between field and consumer largely to the pomologist, the commercial cold-storage man, the retail grocer and the board of health. Forest pathology fortunately has never been thus limited in its outlook; following the able example of Hartig,[4] the study of the diseases of structural timber and the methods of its preservation have been considered as truly a part of forest pathology as the study of leaf spots and other parasitic diseases.

In addition to these self-imposed restrictions there have also been in some cases the additional restrictions of administrative organization. Phytopathological problems were first attacked from the standpoint of the parasites producing diseases. This led to devoting the greater part of the time and effort of the investigator to the parasite, with a resulting neglect of the host and its very important relations. It also led in many cases to the idea that plant pathology included only troubles caused by "germs" or parasites instead of all abnormal physiological conditions by whatever cause induced.

Recognizing that this method of handling the subject was not an entirely satisfactory one, work was organized and divided largely on the basis of the economic host plants involved. This division of the subject has many disadvantages from a strictly scientific standpoint. In the case of parasites attacking several hosts it is necessary to study them in their relations to all their hosts in order to fully understand them and determine their relationships and pathogenic characteristics and to most effectively devise methods of control.

The most recent attempt at the classification of the subject

[4] Hartig, R., "Die Zersetzungserscheinungen des Holzes der Nadelholzbaume und der Eiche," Berlin, 1878.

is according to the physiological effects upon the host. This has much to be said for it, but it also has its limitations.

The ideal method of attacking a pathological problem depends upon the nature of the specific case and should be interfered with as little as possible by system of classification or administrative arrangement. If it be a disease caused by a fungus the life history, relationship and physiological characteristics of the parasite must be studied, also the host reactions and relations under various environments. If the causal organism is found to attack other hosts it should be studied in its relation to these hosts also, whether they happen to be fruits, or vegetables or forest trees.

As a result of these limitations of the field, largely self-imposed by the pathologist, some of the most striking and valuable recent contributions to the science have been made by investigators who were not professionally, at least, plant pathologists. The work of Morse[5] on the cause and nature of the deterioration of asparagus after cutting, the researches of Allard[6] on the mosaic diseases of tobacco, the control of blue mold on oranges by Powell,[7] and of lettuce drop by Ramsey and Markell,[8] and the discovery by Meyer[9] that the chestnut bark disease was native in China and Japan are cases in point.[10]

During the past decade, marked by the establishment of departments of plant pathology in some of our universities and the organization of the American Phytopathological Society, with its journal, "Phytopathology," there has been a marked change in the attitude of plant pathologists toward their work. Recent epidemics of diseases introduced from foreign countries have emphasized and attracted attention to the very important

[5] Morse, F. W., "Experiments in Keeping Asparagus after Cutting," Mass. Agricultural Experiment Station Bull. 172, March, 1917.

[6] Allard, H. A., "Some Properties of the Virus of the Mosaic Disease of Tobacco," *Jour. Agri. Res.*, 6: 649–674, July, 1916. (And other papers in the same journal.)

[7] Powell, G. H., "The Decay of Oranges while in Transit from California," Bu. Plant Ind. Bull. 123: 1–75, 1908.

[8] Ramsey, H. J., and Markell, E. L., "The Handling and Precooling of Florida Lettuce and Celery," Bu. Plant Ind. Bull. 601, 1917.

[9] Fairchild, D. G., "The Discovery of the Chestnut Bark Disease in China," *Science*, N. S., 38: 297–299, 1913.

Shear, C. L., and Stevens, Neil E., "The Discovery of the Chestnut-blight Parasite (*Endothia parasitica*) and Other Chestnut Fungi in Japan," *Science*, N. S., 43: 173–176, 1916.

[10] Throughout this paper no attempt is made at full citations of literature. The papers mentioned are merely by way of illustration. Further examples will occur to any one familiar with the subjects and would be useless to others.

international and cosmopolitan aspects of the subject and the need of a greater knowledge and better provisions to prevent the introduction of new parasites and diseases into this country. A greater breadth of view and to some extent a new spirit are apparent. There is evidence on the one hand that plant pathologists are realizing the obligation laid upon them to extend their studies to wider fields of activity and service and on the other hand there is a new spirit of cooperation among pathologists and students in closely related fields of research.

A Wider Field

In the present awakening of phytopathologists to the real importance and extent of their field most of the self-imposed restrictions are disappearing. Investigators supported by state and federal funds still confine their attention chiefly to single areas, but cooperative effort has widened until we find the pathologists of Massachusetts joining with those of California in the study of a disease of cauliflower[11] and Faucett[12] is able to publish a comparative study of the citrus diseases found in California, Florida and the West Indies. A genuine international Phytopathology[13] was well under way when interrupted by the present war and we find Galloway (I, p. 90) stating as the first of the fundamentals of a new phase of plant pathology, "The work is international."

While pathological research is still confined largely to cultivated plants of economic importance, attention is being given at least to the diseases of newly introduced plants (I), especially to plants of potential economic importance. Work of this type is Harter's[14] study of the storage rot of the dasheen. Scientific data of the greatest future importance will be accumulated if accurate records are preserved of the changing pathological relations of a plant during the period it is being brought under cultivation and its area of cultivation is being extended. No better present opportunity offers than a study of the diseases

[11] Further illustrations of this type of cooperation may be found in Allen, E. W., Wilcox, E. V., Schulte, J. I., "Work and Expenditures of the Agricultural Experiment Stations," 1916, Part I., pp. 18 and 19, Washington, 1918.

[12] Fawcett, H. S., "Citrus Diseases of Florida and Cuba compared with those of California," University of California Publications, Bull. 262, 1915.

[13] Shear, C. L., "Some Observations on Phytopathological Problems in Europe and America," *Phytopathology*, 3: 77–87, 1913.

[14] Harter, L. L., "Storage-rots of Economic Aroids," *Jour. Agri. Res.*, 6: 549–571, 1916.

of the blueberry, now chiefly a wild plant, but already under cultivation and bidding fair to be of considerable economic importance.[15]

As the range of host plants investigated is being widened, so also are the phases of pathology which are being studied. The varied lines of attack on plant-disease problems evidenced in recent publications indicate that plant pathology now includes a wider range of interest than ever before. The chemical changes produced in the host by fungus parasites,[16] oxidation in healthy as compared with diseased plant tissue,[17] the relations between climate and disease,[18] the importance of birds[19] and insects as disseminators of fungus spores,[20] and even the relation between the diseases of plants and those of man,[21] are being investigated.

In particular there is evidence that pathologists are no longer restricting their investigations to production problems. Brooks and Cooley[22] are studying the diseases of apples in storage. The importance of plant pathology in its relation to the loss of perishable fruits and vegetables in transit has been recognized.[23] The somewhat artificial and arbitrary boundaries

[15] Coville, F. V., "Directions for Blueberry Culture," U. S. D. A. Bull. 334 (Professional Paper), 1915.

[16] Hawkins, Lon. A., "Effect of Certain Species of *Fusarium* on the Composition of the Potato Tuber," *Jour. Agri. Res.*, 6: 183–196, 1916. (And earlier papers cited therein.)

[17] Rose, D. H., "Oxidation in Healthy and Diseased Apple Bark," *Bot. Gaz.*, 60: 55–65, 1915.

[18] Stevens, Neil E., "Temperature of the Cranberry Regions of the United States in Relation to the Growth of Certain Fungi," *Jour. Agri. Res.*, 11: 521–529, 1917. (And earlier papers cited.)

[19] Heald, F. D., and Studhalter, R. A., "Preliminary Note on Birds as Carriers of the Chestnut Blight Fungus," *Science*, N. S., 38: 278–280, 1913.

[20] Gloyer, W. O., and Fulton, B. B., "Tree Crickets as Carriers of *Leptosphæria coniothyrium* (Fckl.) Sacc. and Other Fungi," New York (Geneva) Agri. Exp. Sta. Technical Bull. No. 50, 1916.

Gravatt, G. F., and Posey, G. B., "Gipsy-moth Larvæ as Agents in the Dissemination of the White-pine Blister-rust," *Jour. Agri. Res.*, 12: 459–462, 1918.

[21] Smith, Erwin F., "Studies on the Crown Gall of Plants; its Relation to Human Cancer," *Jour. Cancer Research*, 1: 231–258, pls. 1–25, 1916.

[22] Brooks, Charles, and Cooley, J. S., "Temperature Relations of Apple-rot Fungi," *Jour. Agri. Res.*, 8: 139–164, 1917 (and subsequent papers in the same journal).

[23] Coons, G. H., and Nelson, Ray, "The Plant Diseases of Importance in the Transportation of Fruits and Vegetables," Circular 473-A American Railway Perishable Freight Association. Chicago, February, 1918.

Shear, C. L., "Pathological Problems in the Distribution of Perishable Plant Products." Memoirs Brooklyn Bot. Gard., 1: 415–422, pls. ix–xi, 1918.

of the pathologist's work have hindered their entering this important field. Credit is due the pomologists for first attacking the problem of the losses occurring in handling and transportation. Many pathological questions, however, are involved in this work, and a thorough knowledge of the fungi concerned, as well as of the abnormal physiology of the plant products under different conditions, must be obtained. A significant incident in this connection was the appointment in 1917 of a plant pathologist by the Illinois Central Railway. Almost simultaneous and of equal significance in a quite different field was the appointment of a plant pathologist by the American Smelting and Refining Company.

On the establishment of the Food Products Inspection Service by the Bureau of Markets,[24] the chief of that bureau, Mr. Charles J. Brand, requested the detail of plant pathologists to assist in the work. Pathologists were quick to realize their opportunity and have been active in assisting in the work since its establishment.[25] Partly as a result of this, and partly as a result of the world food shortage which called attention sharply to the fact that, at a conservative estimate, thirty million dollars worth of fruits and vegetables are annually lost between field and consumer in this country, the study of diseases of fruits and vegetables in the market is already assuming importance. The phytopathology of the future will not stop when the crops have been harvested, but will extend until the food products are eaten.

There is another source of encouragement for pathologists in the fact that there is a rapidly growing appreciation of the scope and value of their work on the part of the general public and the agencies which provide the financial support for their work. In this connection there is need of greater publicity among city residents and consumers. They should know something of the scope, purpose and practical utility of plant pathology and its intimate connection with their food problems. Millions of dollars, worth of perishable plant foods are destroyed each year in city homes because of lack of appreciation of some of the simplest principles of plant pathology.

[24] Service and regulatory announcements No. 28. Bureau of Markets, U. S. Department of Agriculture. Issued October 31, 1917.

[25] Shear, C. L., "Pathological Aspects of the Federal Fruit and Vegetable Inspection Service," *Phytopathology*, 8: 155–160, 1918.

TEAM WORK

There is no single characteristic by which the new plant pathology is and will be better distinguished than that of team work among investigators. The magnitude of the problems and the angles from which they must be attacked place them out of the reach of a single investigator. We may confidently expect organized "teams" to attack pathological problems in the future; not a group of assistants around a single leader but investigators of training and recognized ability in different lines, each of whom will attack the problem from his own point of view, finally coordinating and combining the results. Such an organization was temporarily formed in the study of the chestnut bark disease.[26] In this case foresters, mycologists, plant physiologists, entomologists and geologists united in attacking a single problem.

A striking example of what may be accomplished by team work is furnished by the workers in Blackman's laboratory who,[27] attacking a problem of great scientific interest from several angles, have contributed notably to our knowledge of the physiology of parasites. In the future we may expect to find mycologists, plant physiologists, and ecologists uniting with chemists, plant breeders, refrigeration experts, entomologists, horticulturists and meteorologists in the solution of problems of plant pathology. With this will go the freest and frankest interchange of ideas among plant pathologists themselves.

Pathologists are coming to realize that cooperation and coordination must be the watchwords of plant pathology as they are coming to be the watchwords in every line of human activity and endeavor. Any one familiar with pathological problems as they present themselves to-day can not fail to realize that no individual however broad his training, or whatever the time and facilities at his disposal, can hope to solve unaided the larger problems now needing attention.

The old idea which has been too prevalent in the past, that the individual investigator may by discovery, preemption or any other means acquire property rights in a scientific problem which will prevent any one else from attacking it, is being abandoned. The advancement of science and the benefit of mankind should be the primary aim and purpose of the pathologist. We are coming to realize that the end is more important

[26] The Publications of the Pennsylvania Chestnut Tree Blight Commission, Harrisburg, Pa., 1915.

[27] Brown, William, "On the Physiology of Parasitism," *New Phytologist*, 16: 109–127, 1917.

than any individual credit, honor or distinction. The all-important question is, how can the problems be solved in the quickest and most effective manner and the results be made most readily available.

Perhaps the most typical manifestation of the new spirit of cooperation is the creation by the American Phytopathological Society of the War Emergency Board of American Pathologists.[28] This board, made up of representative pathologists from different parts of the United States, is effectively engaged in uniting the efforts of plant pathologists on the phases of the great problems of food production and preservation which plant pathologists are peculiarly fitted to solve.

The work of this board may be more properly discussed at a later date, when its activities have produced the important tangible results which are in prospect. It is mentioned here as a recognition on the part of American phytopathologists that their science is, and should be, of great and general usefulness. It is not a science for special interests or special industries. Mankind is absolutely dependent on plant food, and reducing the loss of this plant food both on the farm and on its way to and in the hands of the consumer is the duty of the plant pathologist; a duty which in such a crisis as the present becomes imperative and vital.

[28] "News Items," *Torreya*, 18: 40, 1918.

THE SEASONAL DISTRIBUTION OF SWINE BREEDING

By Dr. RAYMOND PEARL

U. S. FOOD ADMINISTRATION

1. In any analysis of the food resources of a nation the stock and production of swine constitutes a highly important factor. The hog is the primary source of nutrient fat in this country. Considering human food alone, or in other words disregarding fodders and feeds, fat for human nutritive use is derived in about the proportions shown in the following table from all sources.

TABLE I

SOURCES OF FAT, IN CHEMICAL SENSE, PRODUCED FOR HUMAN FOOD IN 1913–1914 IN THE UNITED STATES

Sources	Tons of Nutrient Fat Produced in 1913–14	Percentage Distribution
Pork	2,413,763	41.3
Dairy products	1,721,748	29.5
All vegetable foods[1] (excluding fodders and feeds)	982,964	16.8
Beef	486,373	8.3
Eggs	131,250	2.2
Mutton and lamb	90,405	1.5
Veal	14,679	.3
Total	5,841,182	99.9

From this table the paramount position of pork in our national fat supply is evident. It is clear that any one having the task of safeguarding our food resources must give large attention to the pork supply.

The hog is an animal which reproduces itself relatively rapidly. The duration of gestation is about sixteen weeks, and the sow can be bred any time in the year. Consequently, it is theoretically possible to keep an even flow of additions to the swine population throughout the year. In dealing with the problem of our future pork supply, however, the question arose as to whether, in fact, hogs were bred in this country in such a way as to result in an even birth-rate throughout the year, or whether the breeders' practise was such as to lead to more

[1] Including, of course, cottonseed and corn oils.

births in certain seasons than in others. A special investigation of the point was made, with the results here set forth.

2. To arrive at reliable and representative data as to the birth dates of the swine population recourse was had to the registry records of pure-bred swine of two breeds, the Poland China and the Duroc Jersey. These breeds were chosen because of their popularity and wide geographical distribution in the United States. Frequency distributions of date of birth of litters, by month, were made by extracting at random litter records from the American Poland China Record (Vols. 17 and 18) and the Duroc Jersey Record (Vol. 40). Equal numbers of male and female records were taken. For the purpose of this inquiry the country was divided in four zones on the basis of latitude as follows:

Zone I., Northern Zone—includes Maine, New Hampshire, Vermont, Massachusetts, New York, Michigan, Wisconsin, Minnesota, North Dakota, South Dakota, Washington.

Zone II., North Central Zone—includes Rhode Island, Connecticut, New Jersey, Pennsylvania, Ohio, Indiana, Illinois, Iowa, Nebraska, Wyoming, Idaho, Oregon.

Zone III., South Central Zone—includes Delaware, Maryland, Virginia, West Virginia, Kentucky, Missouri, Kansas, Colorado, Utah, Nevada, California.

Zone IV., Southern Zone—includes North Carolina, South Carolina, Georgia, Florida, Tennessee, Alabama, Mississippi, Louisiana, Arkansas, Oklahoma, Texas, New Mexico, Arizona.

For each zone and breed 500 records were taken at random from the herd books, giving 2,000 records for each breed in total. I am indebted to my assistant, Mr. John Rice Miner, for extracting these records.

TABLE II

FREQUENCY DISTRIBUTIONS, BY ZONES AND MONTHS OF BIRTH, OF 2,000 LITTERS OF POLAND CHINA SWINE

Month of Birth	Births in Zone I	Births in Zone II	Births in Zone III	Births in Zone IV	All Zones
January	1	3	7	41	52
February	13	24	37	34	108
March	103	166	77	48	394
April	239	134	110	84	567
May	86	60	64	58	268
June	17	16	42	37	112
July	8	2	36	33	79
August	7	25	29	26	87
September	10	32	36	32	110
October	11	28	42	46	127
November	3	6	8	39	56
December	2	4	12	22	40
Totals	500	500	500	500	2,000

3. The frequency distributions are given in Tables II. and III.

TABLE III

FREQUENCY DISTRIBUTIONS, BY ZONES AND MONTHS OF BIRTH, OF 2,000 LITTERS OF DUROC JERSEY SWINE

Month of Birth	Births in Zone I	Births in Zone II	Births in Zone III	Births in Zone IV	All Zones
January	5	9	14	29	57
February	13	41	26	10	90
March	189	230	168	90	677
April	170	87	87	114	458
May	53	13	34	61	161
June	13	8	24	56	101
July	5	5	13	28	51
August	6	20	25	12	63
September	21	46	51	19	137
October	13	22	39	29	103
November	4	11	15	24	54
December	8	8	4	28	48
Totals	500	500	500	500	2,000

These frequency distributions are shown graphically in Fig. 1.

Tables IV. and V. give the necessary frequency constants for the distributions.

TABLE IV

FREQUENCY CONSTANTS FOR BIRTH DATES OF POLAND CHINA SWINE

Zone	Mean Date of Birth	Standard Deviation in Date of Birth
I	April 26 ± 1.46 days	48.50 ± 1.03 days
II	May 7 ± 2.17 days	71.79 ± 1.53 days
III	June 1 ± 2.43 days	80.60 ± 1.72 days
IV	June 12 ± 2.95 days	97.88 ± 2.09 days

TABLE V

FREQUENCY CONSTANTS FOR BIRTH DATES OF DUROC JERSEY SWINE

Zone	Mean Date of Birth	Standard Deviation in Date of Birth
I	April 24 ± 1.87 days	61.04 ± 1.32 days
II	May 2 ± 2.45 days	81.28 ± 1.73 days
III	May 20 ± 2.56 days	84.74 ± 1.81 days
IV	May 31 ± 2.69 days	89.24 ± 1.90 days

4. From these tables and diagrams certain conclusions are at once evident.

(*a*) There is clearly considerable difference in breeding practise in different latitudes in this country. In the northernmost zone (I.) the majority of sows are bred to farrow in the spring months March and April, but there is a slight indication of bimodality of the seasonal distribution curve, with the sec-

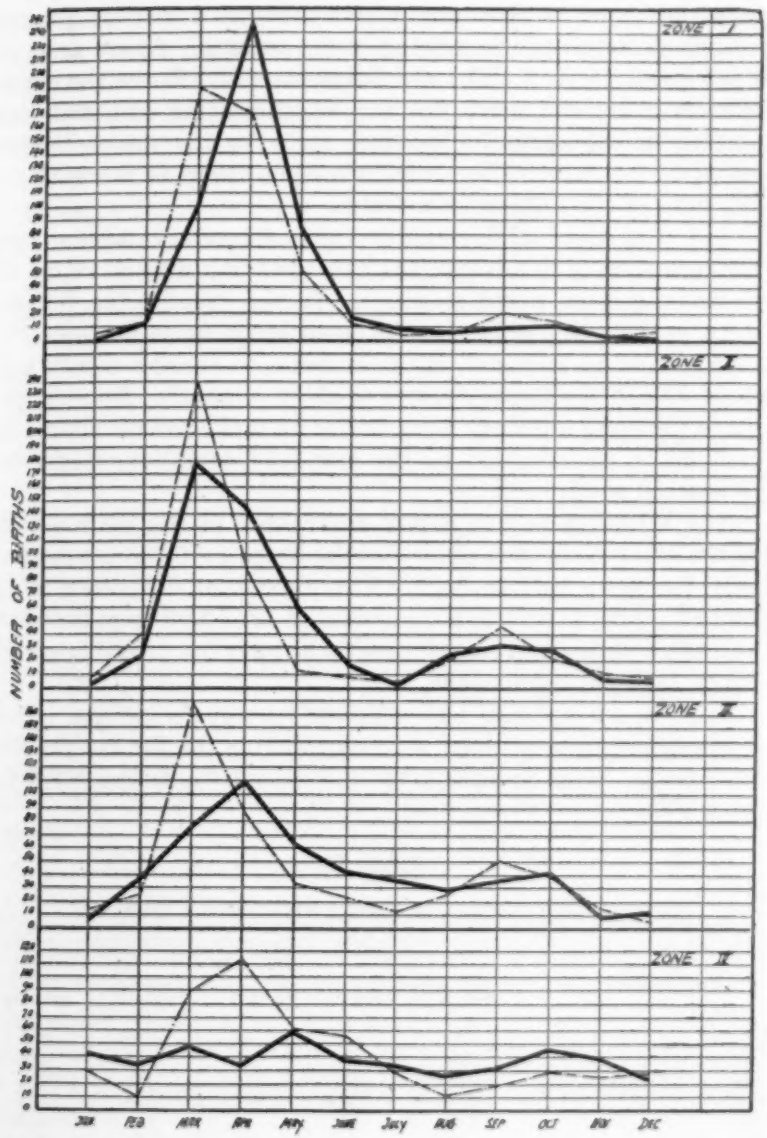

FIG. 1. Frequency polygons showing the seasonal distribution of birth dates in Poland China (solid line) and Duroc Jersey (dash line) swine.

ond peak in the autumn months September and October. In the North Central Zone (II.) this tendency to bimodality becomes much more pronounced and there is a distinct second peak produced by the farrowing in the autumn. As we proceed to the South Central (III.) and Southern (IV.) Zones the curve becomes more and more flat topped, indicating less and less tendency to segregate the breeding period to any one particular season of the year. The spring mode, however, is not entirely lost, even in the southernmost zone.

(*b*) The effect of this tendency to a secondary autumn farrowing season is to advance the average birth date of swine as we proceed from north to south. In the case of the Poland China records this difference in mean birth dates between the north and south amounts, in the extreme, to about a month and a half, and in the Duroc Jerseys to about a month. Another result of the same tendency is, of course, to make the variations in birth dates, as indicated by the standard deviation, larger as we proceed southward.

(*c*) While there are minor differences in the distribution for the two breeds, it is clear that the breeding follows substantially the same rule in both. The maximum difference is in Zone IV., where there is a difference of 12 ± 3.99 days between the means, an amount almost exactly 3 times the probable error, and of doubtful significance.

(*d*) To get a rough but sufficiently accurate general index of hog breeding conditions we may combine the figures for the two breeds. This process gives the distributions exhibited in Table VI.

TABLE VI

MONTHLY DISTRIBUTION OF BIRTHS BOTH BREEDS COMBINED

Month	Frequency				
	Zone I	Zone II	Zone III	Zone IV	All Zones
January	6	12	21	70	109
February	26	65	63	44	198
March	292	396	245	138	1,071
April	409	221	197	198	1,025
May	139	73	98	119	429
June	30	24	66	93	213
July	13	7	49	61	130
August	13	45	54	38	150
September	31	78	87	51	247
October	24	50	81	75	230
November	7	17	23	63	110
December	10	12	16	50	88
Totals	1,000	1,000	1,000	1,000	4,000

(*e*) The essentially bimodal character of the swine breeding curve appears clearly from Table VI. There is a distinct autumn mode but it is only from 20 to 25 per cent. as high as the spring mode. Broadly speaking about three fourths of all the pigs are born in the first half of the year.

According to the official statistics of the Department of Agriculture nearly one half of the country's total hog population is included in our Zone II.[2] Probably this zone contributes two thirds to three quarters of the commercially slaughtered hogs. In Zone II. the following relations hold:

47.3 per cent. of all pigs are born between January 1 and April 1.
69.4 per cent. of all pigs are born between January 1 and May 1.
76.7 per cent. of all pigs are born between January 1 and June 1.

Or, in other words, in the chief swine growing region of the country nearly one half of the pigs are born in the first quarter of the year, and over three quarters of the whole number of pigs are born in the first five months of the year. This assumes of course that we may take the samples of the two breeds here dealt with as indicative of the whole population, which I think we can to a sufficient degree of accuracy.

5. It is of interest now to consider the marketing or slaughter curve for hogs. The Bureau of Animal Industry of the Department of Agriculture maintains some nine hundred stations throughout the country for the inspection of all meat animals received for slaughter. These stations do not cover all the slaughter in the country, but only that of the larger centers slaughtering for interstate shipments; however, they represent in the case of hogs 58.9 per cent. and in the case of cattle 56.4 per cent. of the total slaughter of the country, as determined from the 1910 census.

The following table presents the average percentage that each month's inspection bears to the total for the calendar year, computed from the reported inspections for the six years ending December 31, 1916.

The percentages of Table VII. are shown graphically in Fig. 2, on which is also given for comparison the birth curve in terms of percentage.

From the table and the diagram it is evident that the slaughter follows a very different curve than the births. The most essential point of difference is that the slaughter is much more evenly distributed over the year than the births. The

[2] Cf. Finch, V. C., and Baker, O. E., "Geography of the World's Agriculture," U. S. Dept. Agr., 1917, pp. 130–132.

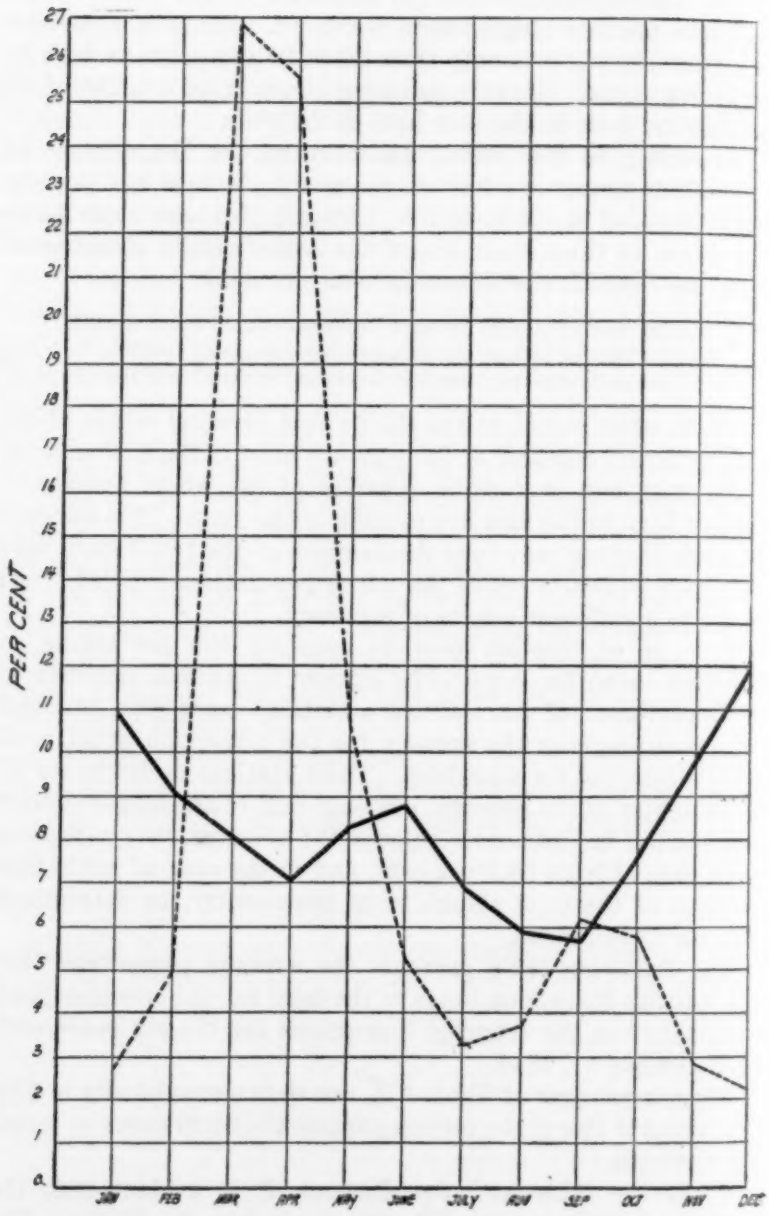

FIG. 2. Diagram showing the monthly slaughter under inspection (solid line) of hogs, expressed as percentage of total slaughter for the year, in comparison with the monthly birth rate (dash line), again expressed as percentage of the year's total.

TABLE VII

INSPECTION FOR SLAUGHTER

Per Cent. that each Month bears to Total for the Calendar Year

Month	Hogs
January	10.97
February	9.07
March	8.08
April	7.10
May	8.22
June	8.74
July	6.89
August	5.82
September	5.64
October	7.13
November	9.88
December	11.98

former curve shows no such violent fluctuations as the latter. During the hot months of the year, July, August and September, the shipments are only about one half those of the winter months, because properly conditioned hogs will not stand shipment and losses are heavy. As the cooler weather comes on, the heavier movement begins and reaches its maximum in December and January, with a decline in each of the succeeding months until May and June, when there is another increase. The two high points of the year in December and June reflect the marketing of the two crops of pigs, spring and autumn, that are produced each year, but in a much reduced degree.

6. What the above facts mean is that there is much more variability on the part of the farmer in the finishing of his pigs than in the breeding of them. To a very considerable extent this removes the potential danger to the nation's food supply which inheres in having 41 per cent. of the nutrient fat supply produced from a source of which 75 per cent. comes into existence in less than one half of the year. The data in this paper show that for all practical purposes the danger point which wants watching is the absolute number of pigs born, not their distribution in different seasons of the year.

THE MARRIAGE OF MUSEUMS

By LEWIS MUMFORD
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I

THERE is something symbolic in the proposal, possibly soon to be effected, to join by a direct path the museums of art and natural history in Manhattan; for it points to a new kinship between these two instiutions that lies much deeper than their supposedly common purpose in fostering learning and spreading culture. Were the tie of education the only one that bound them together there would be no greater fitness in the plan for a connecting walk through Central Park than there would be in one for cutting a driveway between New York University and the American Geographical Society. It is not the aims of the two museums being alike, but their becoming complementary, that gives the proposal a significance. The physical connection will serve to emphasize a cultural borrowing which has at once introduced the presentments of graphic art into the nature museum, and the organic conception of life into the art museum: with the result in certain galleries that the absent-minded visitor will be at loss to recall which museum he is making an inspection of.

The transformation which is taking place in our museums may be roughly described as that from storehouse to powerhouse. The healthy disorder one finds in these institutions today gives evidence of a conflict of traditions which marks this change from a passive "showing off" to an active education, from the uninformed miserly tradition of an earlier day to the directed socialized spirit of the opening age. On the one hand the museum bears all too plainly the stamp of its primitive origin. It is either the robber's cave, the receptacle for princely loot, or the hunter's cache, the repository for animal skins and bleached bones. In both of these capacities it is the function of the museum to acquire as much loot as possible, or as many bones, and to display as great an amount of these in its halls, hit or miss, as space and time will allow. In general, this subordinates esthetic values to those of cash, and scientific values to those of sportsmanlike interest: and to follow this tradition

is not so much to promote science and art as to add renown to the hunter and the warrior, as they existed in their past nakedness or in the various thin disguises of to-day: commercialist and art collector, country gentleman and explorer.

Nominally instituted to further science and art, the museums have been at the mercy of every rich ignoramus who has cared to perpetuate his name to posterity through a respectable interest in cultural activities; and while this handicap has not worked grievously in the domain of natural science, it has spelt disaster in the arts, where such bequests as the Stewart Gallery in the Public Library and the biblical supplement gallery in the Brooklyn Institute swamp those of our Altmans and Morgans in the ratio of about three to one. We may laugh at the savage for burying the trophies of chase alongside the deceased hunter; but on closer inspection the savage has the advantage over us. He at least buries the trophies. We can only remove the dead, whilst, through the operation of legal processes, we allow the trophies an ascendancy over us we would never permit the living to enjoy.

Now the museums can not slough off the trophy-collecting convention by overtly refusing gifts, especially when these are accompanied by funds, and when the slightest hint of aversion would withdraw the support of some pillar of society; but they can nullify the effects of indiscriminate collection by reconstituting the very ends, and therewith the methods, of museum exhibition, so that no object need be kept on view for purely honorific reasons. *It is possible to avoid invidious selection by creating a certain environment within the museum and then trusting to the processes of* natural *selection to weed out objects which are exotic to the environment.* I do not say that this is what the museum authorities are at present consciously attempting; but I do say that their efforts come practically to this conclusion. And it is the tendency to abandon the traditions of the warehouse and the treasure vault, and to make the museum a concrete theater of history, as one follows life from region to region and from period to period, which has given it a new social orientation, and which promises that in pursuing the same goal the two museums will tend to approach within hailing distance of each other. Given a common social basis, collection and presentation will have a common social end: for it is chiefly owing to the absence of any serious purposes that the art and nature museums have seemed to be at cross purposes. Once it is granted that both seek to enrich the meaning of contemporary life by showing men, in colloquial phrase,

where they are at, in relation to ages past and present, and lands far and near, and ancestors, living and dead: once this is granted, the museum is equipped with a criterion of selection to supplement (and in many cases reinforce) the criterion of beauty which prevails in one place, or that of truth-furtherance which holds in the other.

II

While the natural history museum has always nominally kept in mind the conception of a *habitat*, the idea of art's being presented in its social background was for long quite foreign to museum authorities. Art was something apart; by its nature divorced from this world of shadows and at home only in the heaven of platonic ideals; and the museum existed solely to conserve and consecrate objects of art so that men might commune with them within its walls as their fathers in an earlier age communed with God. There was no notion here of the arts being as closely bound to life as the shell to the snail: not to be severed without causing death to the creature or making futile the thing it had erected for its comfort and delight. Rather, it was felt that snails could not only live without shells, but that roundworms could by careful imitation create shells like those snails had once deposited. This attitude toward art, baldly put in metaphor, was the outcome, not of any real break between art and life (for they are joined even in dissolution) but of a divorce between life and those who patronized art; and until a very late date, when the old teachings of Ruskin and Morris began to take effect, the idea of art's being irrelevant to its environment was reflected in the museums. The showcase or the gallery was the exhibition unit; the aim was to admire art as a thing in itself; the subsidiary instruments for satisfying historical curiosity were the guidebook and the professional treatise.

Unfortunately this detached view of art defeated the very aim it thought to serve. There is indeed something to be said for not hedging the esthetic mood with all sorts of secondary intellectual interests, and on the surface the introduction of the social background might seem to provoke a discordance; but this no more holds in reality than (as I shall show) the contrary practise in the museum of natural history. Putting objects of art into what is approximately the environment out of which they have been plucked actually heightens the savor of the art itself, the esthetic note being only fully sounded when every object in the vicinity takes up the note and vibrates in

sympathy with it. This is what is done in the Swiss, the Georgian, and the Queen Anne rooms in the Metropolitan Museum. Were the gallery tradition followed each bed, picture, mirror, or table in these rooms would have been presented, so to say, in severalty: and had the museum been able to put seven fourposters side by side, or a dozen consoles, the supposition would be that the museum was so much the richer. And this would be true from a mercenary and miserly point of view; but it would be a banal distortion from the standpoint of art. Three double beds by Robert Adam in the same room would give the impression that the Walpole ministry had a housing problem in Portland Square; a dozen mantels in one dining room would give currency to the notion that every one used to "eat off the mantelpiece." A plethora of discrete objects, especially when they are the same or similar objects, prevents one from seeing a single object: when the eye is overwhelmed with a horde of creditors crying for attention, it despairs of meeting any demand at all and goes bankrupt. Hence the wisdom of putting art in its proper setting, which means putting it in its place. It is the scientific, environmental presentation that meets all the demands of art. For only when the proper surroundings have been established to provoke the esthetic mood will the esthetic mood lift the observer out of his surroundings.

Plainly this naturalist treatment of the arts, at once historic and esthetic, is but yet in its infancy; and the museum has still many a dusty corner to sweep away before every art collection will have its environment. Certain periods, it goes without saying, can never be done minutely in the grand style, with rooms to illustrate amply phase after phase of significant social life: this would be the true pinnacle of attainment, and a "consummation devoutly to be wished"; but to accomplish so collossal a work of reconstruction at present staggers the imagination, and as a compromise the miniature period stage, as indicated in the models that the Metropolitan is acquiring, enters with an air of importance.

Models have long played no little part in museum exhibition. Those of the Parthenon and of Notre Dame at the Metropolitan are especially well known; and because of their solidity and four-squareness they have a place in the study of architecture that could never be completely usurped by pictures and working drawings. But the new use of models is theatric; it aims at embodying a whole period in a scene. The model-maker takes the scattered materials that have survived the ages, here

a chair and there a table and yon a wall, and he reconstructs in little the details of the society whose relics have been gathered, bringing together on his stage elements that have been widely scattered and showing in concrete, relations which would otherwise have only been dimly perceived. This art, or rather its fresh bias, is not yet sufficiently familiar to permit a final word to be pronounced upon its possibilities: its present status is due to the fine craftsmanship of a single man, Mr. Dwight Franklin. But one can not study the already attained successes with lighting and vividly depicted action without coming to the conclusion that the mimetic representation of past epochs will annex for itself a wide territory in the reconstituted museum, and that the time may come when people, plain and sophisticated, will have opportunity for a glimpse of ancient art and manners (and therewith of social history) through the direct medium of the vision, without being forced to rely solely upon the attenuated descriptions of the printed word. Not as substitutes for the "real thing," but as a method of making real things less strange will models like those foreshadowed in the English Hall or the entrance to St. Sophia's finally be made for every period of significance. Their appearance in the Museum of Art is surely a token of that nascent social interest to which reference has been made. They introduce the notion of the arts as a natural flowering of healthy societies, rather than as a mysterious irruption that somehow, despite a popular love for the false, the vile, and the hideous, intrudes itself upon a society. To see the arts in their proper setting is to restore the organic conceptions of the arts, and the organic conception is that of natural history.

III

But if the art museum is espousing the methods of science with its emphasis upon the continuity of living things, and the relation of organism to environment, and craftsman to period, it is no less true that the science museum is taking advantage of the synthetic vision of the artist. So far from being occupied with the purely cognitive aspects of the natural sciences, the American Museum has been increasingly eager to develop their emotional aspects and to further their application to the arts. This has been done in three ways. In the first place, art workers have been encouraged to make use of the primitive patterns created by the indigenous American craftsmen of the loom and the potter's wheel. The result of this has been to lengthen our historical perspective and to detach the workers

from a perhaps too close apprenticeship to European models. These borrowings from a more primitive culture break down the ancient Greek antithesis between nature and art by means of the arts created by the so-called nature-peoples; and by bridging the gap between the two separate fields it has brought the museums that represent these fields into a closer working community.

The second phase of the museum's artistic activity has been in the reconstruction, first in drawings and then in single cases and now in whole galleries, of the natural habitat of the wild creatures whose lives are to be portrayed. No mention of this return to nature in the study of nature could be made without reference to the work of Mr. Charles Knight. Combining scientific penetration and artistic insight in a remarkable degree he has in his drawings, from the first water-color sketches of our saurian ancestors, divined from the meager evidence of a rag, a bone, and a hank of hair, to the last sweeping mural of the hairy mammoth, effaced by the synthesis of his own personality the ill-conceived antagonism between science and art that was handed down from an earlier age. That without the love and the beauty of nature there can be no geography or no nature study worthy of the name has already been urged by the eminent botanist, and art critic likewise, Patrick Geddes. But conventional practise sterilized this love and made abortive this beauty by isolating art in a peculiar building, as though it were a contagious disease, at the same time that it reduced nature study to a mere grind of names. From this paralyzing practise the artist-scientist is cutting loose. He places his art at the service of science, and he uses his science as a frame for his art: and he has thus to no little extent given back to the artist the opportunity for public service which disappeared with the decline of the middle ages and the usurpation by the leisure classes of the artist's talent for the gratification of idiotic whimsies.

The decoration of nature backgrounds for animal groups is but the recovery for the new cosmogony of those religious interpretations which have a hallowed place in medieval churches. And the fact that the interest in nature *per se* is contemporary with the development of landscape painting (due in both cases to the arousal of a new, non-invidious curiosity in things) is perhaps an indication of the essential reasonableness in calling in the landscape painter as an aid to the naturalist. This is a new field of the artist of realist tendencies: it opens the way for an escape from "gallery art," while it gives the *photographer*

of contemporary esthetic derision a fresh raison d'être and a refurbished purpose in life. Here is also at last a place for those academics and scholiasts who in the teaching of art insist upon truth values, those of anatomical perfection and fidelity to exterior form, as the salvation from slackness, laziness, meretriciousness and the like. Losing their foothold inch by inch in the art galleries, they may at least find refuge without compromise in our museums of natural history. I do not point out this possibility in irony. The classicists in art have still a place left for them in society, as the creators of decorations that aim to establish a moral, a civic, or a scientific truth through the medium of art. And it is only within the very narrow sanctuary of pure esthetic being that the incense they offer on the altar of truth pours upward in a heavy fume that conceals all the delicate beauties of the little temple. In the museum of natural history their craft is not to be despised; for the technique of naturalism is largely an objective technique; and its logic is the single one that will accommodate itself to values extraneous to those demanded by an absolute esthetic response. Despite the difficulties offered by walls whose surface is marred with useless windows and by galleries which were never meant to serve the ends of esthetic contemplation, the artist has much in the nature museum to spur as well as hinder his technique. And beyond doubt the new additions to the Natural History Museum will be planned in full recognition of the artist's coeval interest with the scientist in the most effective display of a collection in its manifold aspects.

The third manner in which the museum has utilized the artist is by employing him to render models in plaster and wax of animals, man for one, that defy the most adept efforts of the taxidermist. Here is a province that the sculptor of highest rank need not disdain to tread. Consider the opportunities offered by one of the life-sized or slightly reduced groups of peoples engaged in their native occupations; such a group as that of the Pueblo dwellers, for example. In many ways the ethnic casts made by the museum workers are beyond approach: they are faithful in all the minutiæ which patience and manual skill can take care of, and they appear against such ably conceived backgrounds that it is not easy to detect wherein they fall short of the highest. Examining with more critical eye the figures themselves, however, one gets the sense of a lost opportunity, and one feels that in order to measure up to the scientific accuracy of the setting as a whole the figures should have been done by as skilled a hand as knows how to use modeling

tools—that here is a subject which might tempt the genius of Phidias or Praxiteles or which might in our own day have enlisted the hand of such a many-faceted master as Rodin himself. Is it too much to expect that the museum of the future will include along with its numerous and capable artists of the brush an array of naturalist sculptors whose quality will be little, if any, below the finest offerings of their contemporaries?

The interest of the age is above all scientific: why then should it not use art creatively for its purposes? The great statues of Greece and Rome were found in the baths and gymnasia and theaters; for there the cultured life of the time was centered, and the artist was called upon to enrich the meaning of that life by transfiguring its quality in marble. To-day we have not lost these interests, but we have added to them the impassioned curiosities of science; and the Milesian Venuses and Indian Bacchuses of another day have a niche awaiting them in our museums of natural history. Who but the sculptor with undisputed mastery should perpetuate for us the subtly molded human figure, differing as it does from race to race and climate to climate. The present figure groups in the museum are but a beginning. They do no more than represent the grosser divisions of the human race, as between Bushman and Kaffir, between Chinaman and European. And even here, in lieu of a robuster ideal of art, there is a perpetual baffling of the scientific interest by differentiating not between men as animals, but between men as the lay figures of civilization, a Chinese farmer being placed alongside a Norwegian matron, each in the regalia of daily life, as though the sculptor had been dismayed by his deficiencies and had thought to conceal them under the obvious camouflage of clothes. Further than this naïve revelation of types the museum must soon go; but it can obviously not travel far until the highest range of artistry is incorporated in its staff. This is not to disparage present achievements: it is rather to acknowledge their worth by showing to what heights they draw the imagination. Once let the scientific impulse get hold of the sculptor (who is an anatomist by current practise anyway) and a new horizon of possibility will open up for both science and art.

In the statuary exhibited last year by Mr. Charles Knight there is a hint of how deep the communion of purpose may be when once it is realized that knowing and feeling are not warring "faculties" of the mind, but diverse attitudes which men assume at appropriate times in their endeavor to have commerce with the things that lie about them. Any emphasis

of antagonism is more than banal: it is ignorant. Both science and art are means of opening that oyster, which is the world; and if the one seeks chiefly to dissect the bivalve while the other loses itself in contemplation of the pearl, this should not obscure the fact that they must open the same oyster, and that they may well, for the attainment of this mutual end, take hold of the same instrument and use their forces jointly. It is this truth that is coming to be recognized in our museums as they abandon their primitive reasons for existence and seek to justify their further extension by activities which harmonize with the democratic sympathies of the present order. Hence the environmental treatment of the arts in the art museum; hence the artistic presentation of nature in the nature museum; hence the shift in accent, but not in aim, as one passes from one museum to the other. This perception of a common and complementary purpose indicates, I believe, something like a marriage between the two kinds of museum; a union which might well be sanctified by civic authority in a connecting pathway.

WHAT IS SOCIOLOGY?

By Dr. F. STUART CHAPIN

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IN the public library you find grouped under "Sociology" such a bewildering variety of books that the name sociolgy seems to be a vague term quite devoid of definite content and without specific limitation. Books on economics, social psychology, penology, anthropology, philanthropy and the like, are promiscuously corralled together. Some writers on sociology have maintained that sociology is the great synthetic social science which, by combining the generalizations of the special social sciences, economics, politics, ethics and philanthropy, arrives at a scientific reality quite different from the particular elements entering into the combination, and by this reason alone, worthy of an independent and dignified place in the hierarchy of sciences. This has prompted the critic to say that then sociology is "a little bit of everything and nothing at all."

On the other hand, sociology may mean to the graduate student at the university such a definite thing as that body of principles which govern the evolution of society from primitive forms to its highly complex modern form. To the social worker, sociology may mean the very definite body of scientific knowledge involved in successful social legislation or case work.

Is it hopeless to unravel the tangled skein? I think not.

Scientific progress in sociological writing, on the one hand, and in concrete practical achievement, on the other, has been so rapid of late years, that there has tended to develop an entirely natural but a very deplorable misunderstanding between the writer-teacher group and the practical social workers. This situation may be readily understood by a moment's consideration of a few relevant, though often neglected facts.

In the first place, it should be recognized that certain overacademic and superficial writers have brought the serious scientific group of writer-teachers into disrepute among many practical workers. But it is equally true that a small element of self-advertising "uplifters" has brought the social worker group into disrepute among many of the writer-teacher group.

Now a careful examination of the best work of the writer-

teacher group represented by Franklin H. Giddings, Lester F. Ward, William G. Sumner, Edward A. Ross, Charles H. Cooley and Charles A. Ellwood, to mention a few by name, shows that the common subject-matter of their writings is those massed and correlated psychic elements variously known as social customs, standards, traditions, institutions, fashions, conventions, folkways and mores. All of the profound theoretical, evolutionary and historical studies of these writers, however academic they may seem to the practical-eyed social worker, are but scientific efforts to discover, formulate and define those principles which govern the origin, growth and evolution of our modern social customs, standards and institutions.

Similarly, a careful examination and evaluation of the work of the practical group of social workers, however foreign it may appear to the interests of the others, reveals the fact that the common end of all their efforts is to restore normal standards, to encourage helpful traditions, and to preserve and upbuild normal social institutions. They restore to normal standards the flood-stricken community. They rehabilitate the disorganized family.

Thus it is seen that the two groups, of students and of workers, are really laboring in the same field, upon a common subject-matter. This fact has received tacit recognition in such recent sociological books as Blackmar and Gillin's, "Outlines of Sociology," and in Hayes's "Introduction to the Study of Sociology," and by the establishment at Western Reserve University of a school of applied social science. But it should be given an immediate, more general and cordial recognition on the part of both the writer-teacher group and the social-worker group. In proportion as this is done, the discoveries of the two groups of scientists will become gradually articulated into that body of tested scientific principle which is so much needed to solve the pressing problems of our democratic social order.

But have we answered the question, what is sociology? Having cleared the air of misunderstanding and discovered the common ground of interest, let us proceed to answer the question directly.

Says Professor E. C. Hayes, "The problem phenomena of sociology are of one clear and distinct class, as much so as those of the best established sciences," and he continues, "Sociology must deal with massed and correlated psychic elements, and with environmental factors of every kind by which social customs and institutions are effectively conditioned." Now it will

be admitted that the special social sciences of politics and economics, as well as the science of psychology, do not treat the phenomena of social customs, standards and institutions as their chief subject-matter. Indeed, these sciences treat such social phenomena, if at all, only as incidental to the special subject-matter of each. Thus there have been left over the important residual problems of the origin and growth of social customs, standards and institutions, and these problems have become the special field of a legitimate and independent science—sociology.

The science of sociology, like some other sciences, may be divided into two branches: *pure sociology*, that is, theoretical and historical sociology (sometimes styled "scientific sociology," but erroneously so designatd if the term implies that the other branch is not scientific); and *applied sociology*, variously called social pathology, or social economy, or social legislation and social work.

Pure sociology is concerned with the laws that govern the origin, growth and evolution of social customs, standards and institutions. It analyzes social phenomena into its elements and seeks to explain the relative importance of such conditioning phenomena as biologic (for example, are the standards of one race low because of native inferiority?), geographic (or, are the standards low because of paucity of natural resources or isolation?), technic (or, are the standards low because of perverted attempts to control nature or to interfere with natural processes?), and social (or, are standards low because it is a young race and lacks length of social experience?). Thus in so far as pure sociology throws new light on old problems by assembling the data of biology, geography, psychology and anthropology, it is synthetic; in so far as it assembles statistical data and discloses new and unsuspected relations, it is inductive.

Applied sociology studies the causes that force human beings individually and collectively to live below those "normal" standards of living which are exemplified in the prevailing customs, traditions and institutions of the time (as analyzed and defined by pure sociology). Thus it studies the causes of poverty and dependence, the causes of crime, and the social causes of sickness and disease. But applied sociology also endeavors to discover the principles (and here it should borrow from pure sociology), and to develop the technique, which, when applied, will either prevent the recurrence of socially pathological conditions, or at

least relieve the abnormal situation. For example, the principles of case work applied to family rehabilitation; the individualization of punishment to secure reformation; and the introduction of investigation, follow-up work and ideals of restoration to self-support, into the practise of poor-relief.

Briefly stated, pure sociology traces and defines normal human tendencies and standards; applied sociology endeavors to preserve and re-establish them.

We may therefore define sociology as the science of the origin, growth and evolution of social customs, standards and institutions. It analyzes and defines them, and studies the causes that tend to force people below normal standards, thus showing us how to prevent recurrent lapses from these norms, as well as to relieve abnormal conditions.

PALEONTOLOGICAL EVIDENCES OF THE ANTIQUITY OF DISEASE

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PATHOLOGICAL conditions among fossil animals are known as far back in geological time as the Carboniferous, hence it may be proper to state on the basis of our present knowledge that disease began, among both plants and animals, during the great Coal Period. These evidences are found both in the new and the old world, so that there must have been a very fundamental condition underlying the evolution and development of animal and plant races which favored the ingress of disease and the overpowering of the natural immunity which had previously protected the forms of life from the devastations of disease. This statement of affairs implies the absence of disease, or of a tendency toward disease, among the inhabitants of the earth during the geological periods prior to the Mississippian. This may not be correct, but so far as we know at present the animals of the Paleozoic and Proterozoic were free from disease. The factors which have been important in the origin of disease have been discussed by the writer[1] in an essay which had in view an outline of the entire subject of the origin and development of disease as seen in the lesions on fossil bones. A study of senescence in dogs and the relation of old age to disease recently made by Goodpasture[2] supports in an interesting manner a suggestion made by the writer[1] concerning certain factors in the origin of disease among the animals of past ages.

CARBONIFEROUS

Present evidences tend to show that the Coal Measures witnessed the origin of disease. The oldest known evidences of pathological conditions among fossil animals are to be found in the enlarged stems of fossil crinoids, which have been known for many years. They were described by Robert Etheridge, thirty-eight years ago, from the Carboniferous of Scotland. Five years later a correct interpretation of these deformities was given by L. von Graff. He showed, on the basis of similar

[1] "Studies in Paleopathology. I., General Consideration of the Pathological Conditions found among Fossil Animals," Annals of Medical History, Vol. 1, No. 4, 1918.

[2] "An Anatomical Study of Senescence in Dogs, with especial Reference to the Relation of Cellular Changes of Age to Tumors," *Journ. Med. Research*, Vol. XXXVIII., No. 2, pp. 127–190, 1918.

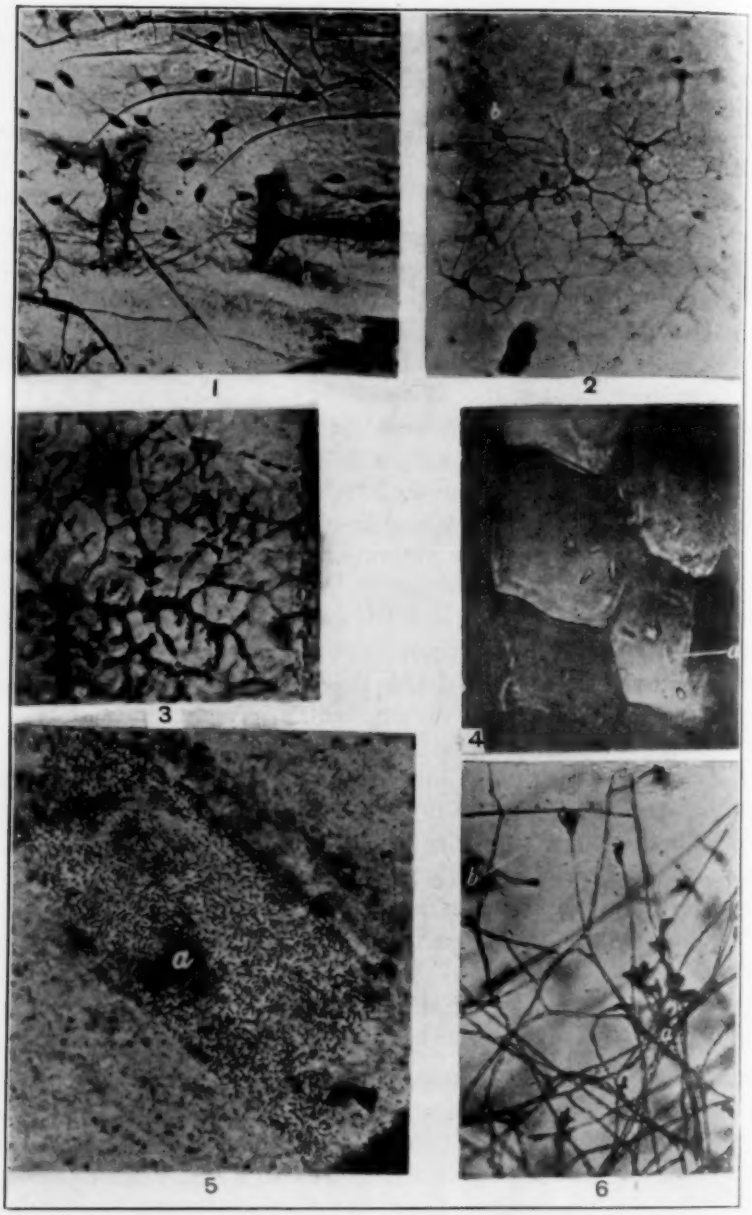


FIG. 1. PHOTOMICROGRAPH OF A FRAGMENT OF FISH BONE FROM THE AUTUN BASIN OF FRANCE, showing the nature of the osseous lacunae, canaliculi and vascular channels.

FIG. 2. PHOTOMICROGRAPH OF ANOTHER PORTION OF THE SAME BONE showing in the enlarged canaliculi and lacunae the ravages of micrococci which have invaded the channels and have begun the destruction of the bone.

FIG. 3. PHOTOMICROGRAPH OF ANOTHER PORTION OF THE SAME BONE showing a further stage of destruction. The form of the lacunae and canaliculi are barely perceptible, since they are packed full of colonies of micrococci.

FIG. 4. SCATTERED BACTERIA IN FOSSILIZED PLANT CELLS, one of them at *a* showing faint indications of a mucoid capsule.

enlargements among recent crinoid stems, as described and figured in the Reports of the Challenger Exploring Expedition, that these enlargements were due to the parasitic action of myzostomids. Graff supported his interpretation by describing the carbonized remains of some worm, supposedly one of the myzostomids, to which the tumor was due, preserved in a channel of one of the fossil lesions. Similar objects are common from the Carboniferous of North America and doubtless they have a very wide distribution.

During the Carboniferous also there was a widespread development of fungi and bacteria which doubtless were influential in the spread of disease. Renault has found these forms abundantly preserved in the fossilized feces of fishes, in ancient wood and in coal. He also discovered in the teeth of certain extinct fishes indications of caries, as shown by the irregular decayed spots within the substance of the teeth. Renault's work covered many geological periods later than the Coal Measures, and his large monograph is the summing up of twenty-four years of activity spent in investigating the nature of the "Microorganismes des combustibles fossiles" in peat, lignite, bituminous schists (in which he found rhizopods, bacteria and fungi), boghead coal, cannel, ancient schists and the silicification of organisms in very ancient rocks. Renault's work is of great importance. A few of his figures are given herewith (Figs. 1–6). The bacteria take the form of coccoids, bacilli, diplococcoids and micrococcoids. Often in sporangia of the early cryptogamous plants Renault found natural cultures (Fig. 5) of bacteria which have been preserved by silicification. These organisms, which have been made so well known by the studies of French scholars, may all of them have been non-pathogenic forms, but the possibility of their being the cause of the disease of succeeding forms of life is very evident, and they should be mentioned as possible sources of disease.

PERMIAN

The great Permian period, with its widespread development of curious reptilian forms, has furnished us with the first evidences of traumatic conditions as they prevailed among the early forms of life. Fractures may have occurred earlier than the Permian, but they have not yet been seen. The oldest known fractures are found among the reptiles from the Permian of Texas. A left radius of *Dimetrodon*, a primitive reptile, pre-

FIG. 5. SILICIFICATION OF A NATURAL CULTURE OF BACTERIA FROM THE PERMIAN.

FIG. 6. MYCELIA AND SPORANGIA OF FOSSIL FUNGI as seen under high magnification in a thin section of fossil wood. Favorite places for the growth of bacteria. All figures taken from Renault's monograph "Microorganismes des combustibles fossiles."

FIG. 7. LEFT RADIUS OF *Dimetrodon*, a primitive reptile from the Permian of Texas, showing, in the enlarged portion of the bone above, a simple fracture and considerable callus with some intermediary callus. Specimen the property of the Walker Museum University of Chicago. Loaned for study and description by Dr. S. W. Williston.

FIG. 8. X-RAY PICTURE OF THE BONE. The fracture lines above and below the callus are post-fossilization fractures and have no significance.

sents a well-marked case of fracture (Fig. 7) with subsequent healing, although there is still some intermediary callus. An attempt to study the nature of this fracture by means of the X-ray has not resulted in any new knowledge, but it may be interesting to present the attempt (Fig. 8). The fracture runs directly across the bone, as do all the early cases of fracture among animals with solid limb bones, and the resulting callus has produced a decided enlargement of the bone around the fracture. The fractures seen in the X-ray picture above and below the callus were produced after fossilization and have no significance.

A small fragment of a fractured rib from the same beds, in which there was quite an old callus, has been studied micro-

scopically (Fig. 9). The callus was quite evidently an old one, for the fracture was completely healed. A study of the microscopic section proves this to be true, since evidences of osteosclerosis and osteohypertrophy are clearly evident. The region

FIG. 9. MICROSCOPIC STUDY OF THE DETAILS OF A FRACTURE IN A RIB OF A REPTILE FROM THE PERMIAN OF TEXAS. The white spicule running vertically in the figure is the ingrowth of bone into a split portion of the rib. On the left of this spicule is to be seen the osteosclerotic portion of the old callus, indicated by a heavy unorganized deposit of calcium carbonate or some similar salt. On the right is seen the hypertrophied area, identified by the heavy deposition of bone with small lacunae and canaliculi. The lacunae have largely disappeared in reproduction but are clearly evident on microscopic examination of the bone.

of the figure to the left of the spicule of bone is regarded as due to osteosclerosis, which is interpreted on the basis of the presence of a heavy deposit of calcium salts and the absence of osseous trabeculae. The white band running vertically may be interpreted as a spicule of bone due to the splitting of the rib. Its bony nature is definitely established by the presence of lacunae, and its presence in this position is due to the ingrowth of new bone along a cleft produced by the splitting of the rib. The hypertrophied area to the right of the osseous band is often seen in old calluses and is interpreted on the basis of the presence of numerous trabeculae of bone. There is no evidence that the fracture was infected, necrotic sinuses being entirely wanting.

TRIASSIC

Except for occasional specimens of fossil fishes and other forms preserved in the pleurothotonos and opisthotonos (Fig. 10A), attitudes suggesting a condition of spastic distress,[3] little is known about the pathology (Fig. 10B) of the animals which

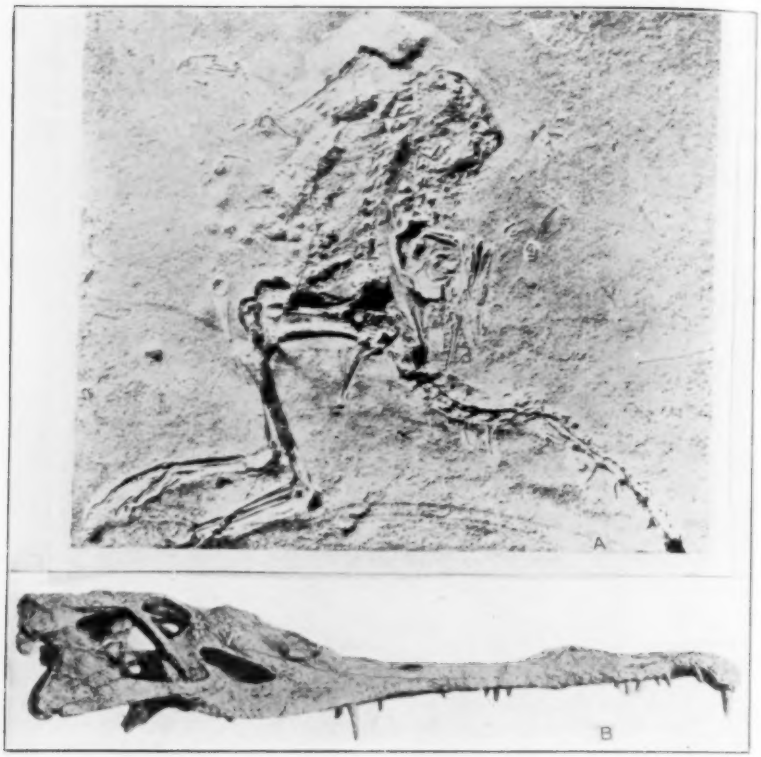


FIG. 10A. THE SKELETON OF *Compsognathus longipes*, a small Triassic dinosaur, fossilized in the position of opisthotonos, a position which has been suggested as an evidence of cerebrospinal infection. The head is thrown far back over the pelvis and tail thrown sharply up with the feet and limbs in a spastic attitude.

FIG. 10B. THE SKUEL OF *Mystriosuchus Plieningeri* H. von Meyer, a parasuchian, from the Triassic of Aixheim, exhibiting a broken snout (above letter *B*) with resulting callus and bone necrosis. After Huene.

lived during the Triassic. There doubtless is much to learn in the future, since many vertebrate species are known from this period.

JURASSIC

The Jurassic of England furnishes us the first evidences of necrosis and a suggestion of metastasis as seen in the pathological nature of the bones of *Metriorhynchus moreli* Desl., a crocodile described by Erwin Auer[4] from the Oxford Clay.

The skeleton of this interesting animal was only partially preserved. There are evidences of pathology in the palate, on the two femora, on a sacral vertebra and on the pelvis. Auer says:

[3] "Studies in Paleopathology. III., Opisthotonos and allied Phenomena among fossil Vertebrates," *American Naturalist*, Vol. LI., No. 617–618, 1918.

[4] *Paleontographica*, Bd. 55, pp. 277, 279–280, figs. 13–14.

On the middle of the inferior side of the palatine is a section that is unusually differentiated by cavities, and consists of fossulae, a condition that is not otherwise encountered in crocodiles, and that doubtless is connected with the pathogenic deformities the bones exhibit.

The right femur is normally formed, but it displays below the caput femoris a peculiar corrosion, and the condylus internus is reduced at the distal end.

The left femur (Fig. 11*a*) departs in form quite considerably from the normal type. The head of the bone has undergone a significant contraction, and the formerly globular articular surface is deformed. Under

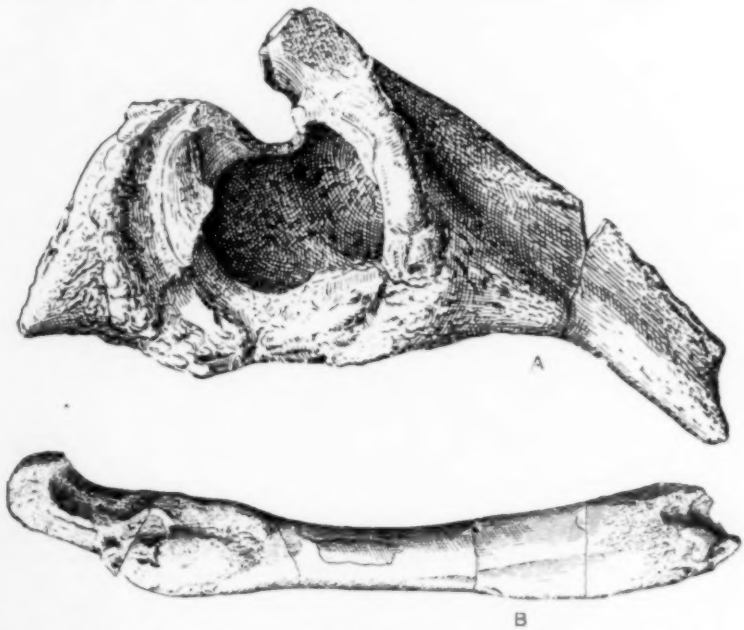


FIG. 11*A*. SACRAL VERTEBRA OF *Metriorhynchus moreli* Desl. from the Oxford Clay of England, showing carious roughening and necrosis. After Auer.

FIG. 11*B*. LEFT FEMUR OF THE SAME, showing pathological roughening at the upper and lower extremities, especially around the trochanetric region. After Auer.

the head of the bone the femur exhibits an abnormally small diameter, and on the external side of the bone a ridge is raised.

The sacral vertebra (Fig. 11*b*) also exhibits significant deformities of a pathogenic nature; the body of the vertebra is noticeably thickened, irregularly jagged on the outer side and set with numerous rather deep holes. The body of the vertebra is completely hollowed out from the end surface.

The description indicates the presence of a tuberculous or similar necrosis of the bones and is the most complete example of a seriously diseased vertebrate which has been seen in the fossil condition.

COMANCHIAN

The gigantic dinosaurs of the Comanchian have long been known to have suffered from disease and injury and the writer

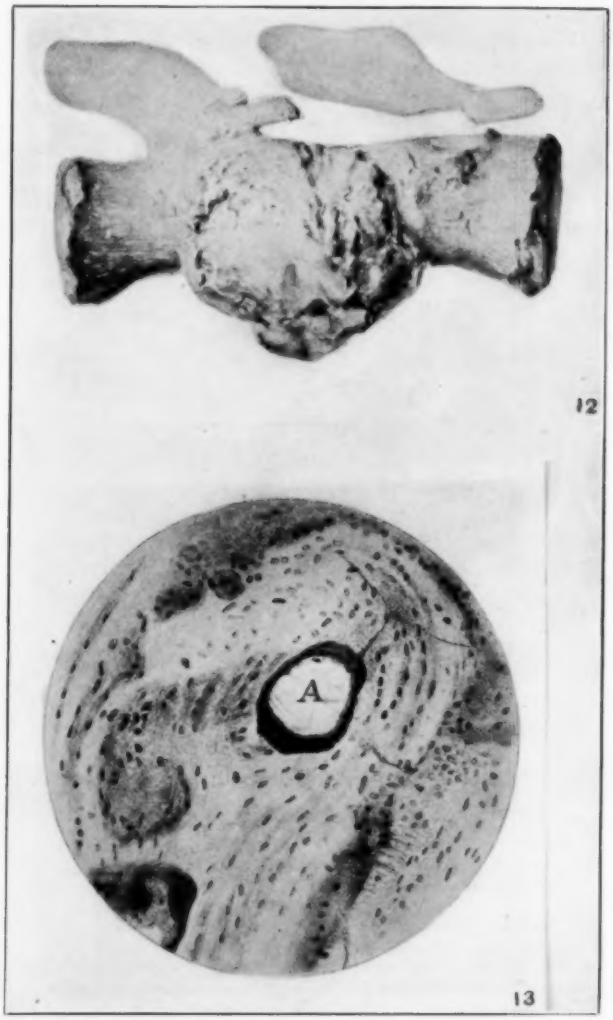


FIG. 12. DEFORMED JOINT BETWEEN TWO CAUDAL VERTEBRAE OF A DINOSAUR (*Apatosaurus*) caused by the growth of a tumor-mass, which on account of its extreme vascularity represents possibly an haemangioma, or some similar pathological growth.

FIG. 13. MICROSCOPIC SECTION OF A PORTION OF THE PERIPHERY OF ABOVE TUMOR, showing arrangement of lacunae, vascular spaces (*a*) and lamellae of bone. How much this differs in arrangement of elements from normal bone remains to be determined.

has described these sufficiently in other places[5] to make their characters well known. The most interesting lesion seen among the dinosaurs has been regarded as resembling a modern hemangioma (Figs. 12–13). Fig. 14 will show the nature of the

[5] "Pathologic Lesions among Extinct Animals: A Study of the Evidences of Disease Millions of Years Ago," *Surgical Clinics of Chicago*, Vol. 2, No. 2, pp. 319–331, Figs. 108–116, 1918.

vascular spaces and the arrangement of the osseous trabeculae as seen in a sagittal section of the tumor mass.

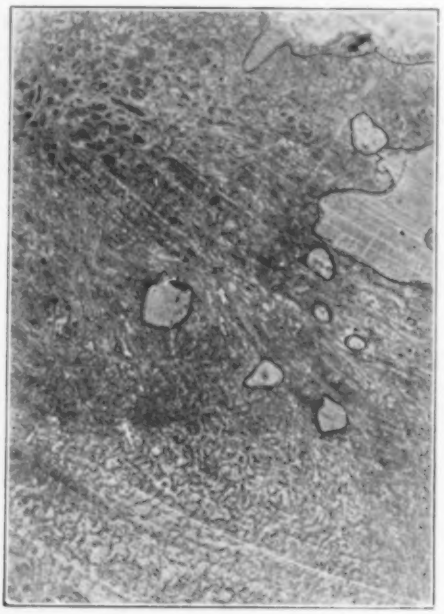


FIG. 14. PHOTOGRAPH, ENLARGED, OF THE CUT SURFACE OF THE TUMOR SHOWN IN FIG. 12, to show the arrangement of the trabeculae of bone and the large vascular spaces (areas outlined in ink). The large area at the top of the figure is apparently a portion of the intravertebral space, which has become largely obliterated by the growth of the tumor. The substance of the chevron, seen in Fig. 12 as portion of the tumor, has been incorporated, when seen in section, with the mass of pathological bone.

CRETACEOUS

The diseases of the mosasaurs may be taken as a sample of the prevalence of disease and injury among the vertebrates of the Cretaceous. These aquatic vertebrates, as well as their congeners, the plesiosaurs and dinosaurs, were afflicted with a variety of diseases and the writer has been able to study the details of the lesions on the fossils from the Cretaceous of Kansas. Twenty years age Doctor Williston called attention to the diseased nature of the arm bones of one of the Cretaceous mosasaurs. Recently I have been able to study these bones (Fig. 15). Their pathological nature and the exostoses of a hyperplastic nature are at once evident (Fig. 15). A tentative diagnosis of osteoperiostitis has been given as the cause of the lesions. Microscopic study of the lesions (Figs. 16 and 17) reveals the bony lamellae laid down in a concentric manner, as if to form Haversian systems. The lacunae are relatively large

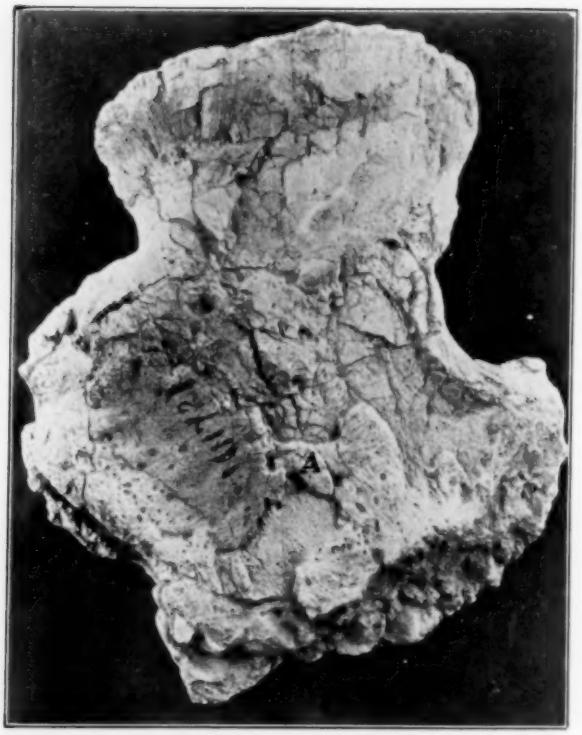


FIG. 15. HUMERUS OF A MOSASAUR, *Platecarpus coryphaeus*, from the Niobrara of Kansas showing the details of pathological lesions resembling those seen in modern osteoperiostitis. The microscopic sections (Figs. 16–17) were taken from the lesion at *A*. The disturbance also involved the articular surfaces indicating the presence of an arthritic infection.

and are provided with short canaliculi, and there are areas where osteoid tissue (Fig. 16) is present, comparable in every way with osteoid tissue, seen in modern cases of osteomyelitis. For the first time in the history of paleohistology perforating fibers of Sharpey (Fig. 17) are seen running through the sections.

A dorsal vertebra of *Platecarpus*, a well-known mosasaur from the Cretaceous of Kansas, presents an extremely interesting example of an osteoma (Fig. 18), the only one thus far known in a fossil condition. The specimen has not yet been studied microscopically, but a gross examination of a sawn section (Fig. 19) through the osteoma and vertebra shows in a very interesting manner how the tumor mass grew out of the vertebra. An X-ray examination of the bone reveals nothing of importance.

A radius of another mosasaur shows on the proximal surface an extensive necrosis. Sections of the bone show hyper-

FIG. 16. PHOTOMICROGRAPH OF THE PORTION OF THE LESION (A, Fig. 15), showing osteoid tissue. The black lacunae are seen to be without canaliculi and their arrangement in concentric lamellae suggests the presence of an Haversian system. The dark area running obliquely out of the lower left hand corner is a post fossilization fracture filled with calcite. This area of osteoid tissue in the humerus of a mosasaur, 15,000,000 years old, is identical in anatomical structure with osteoid tissue from the human humerus in a case of osteomyelitis.

trophy of the peripheral substance. The nature of the organism producing the necrosis is not determined, but the fossil presents an exact duplicate of modern instances of extensive arthritic necrotic sinuses, which result in hypertrophy and the production of numerous osteophytes.

Dollo has described dental caries in a mosasaur jaw, with a hyperplasia of the bone with accompanying necrosis, as if the creature had suffered from a mouth infection similar to modern alveolar pyorrhea. The results are identical in modern and ancient bones.

The prevalence of disease reached a climax in the mosasaurs, dinosaurs, plesiosaurs and turtles of the Cretaceous, and with the opening of the Tertiary the incidence of disease went sharply down, to rise again with the rise of mammalian life and reach a very high point during the Pleistocene.

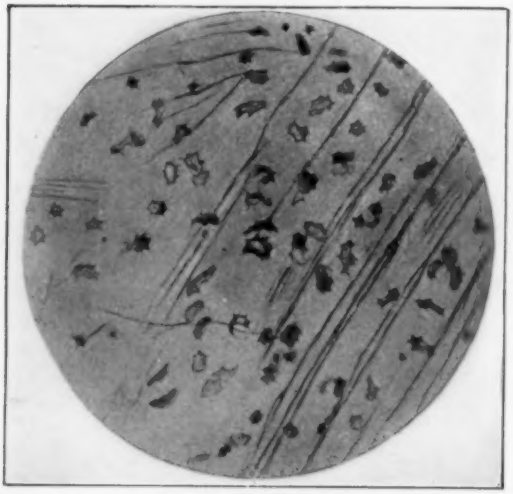


FIG. 17. MICROSCOPIC STUDY OF ANOTHER AREA OF THE SAME SECTION AS THAT SHOWN IN FIG. 16, showing the presence of perforating fibers of Sharpey, the long black fibers running obliquely through the figure, and small lacunae with short canaliculi, without any definite arrangement into systems.

FIG. 18. A DORSAL VERTEBRA OF A MOSASAUR, *Platecarpus*, from the Niobrara of Kansas, showing on the posterior (right hand of figure) end of the vertebra an osteoma, the only known fossil representative of this type of tumor.

EOCENE

The extinction of the large groups of reptiles at the close of the Cretaceous doubtless brought about the disappearance also of many forms of disease which attacked these animals. Some forms of disease, as seen in the lesions left on the fossil

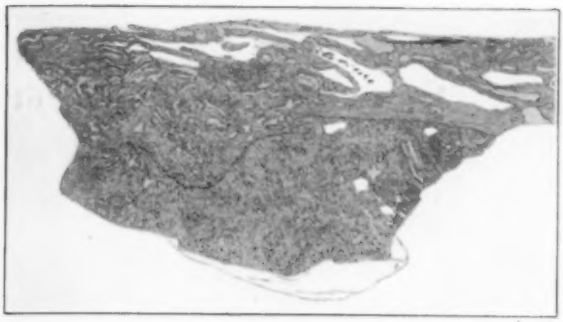


FIG. 19. A DRAWING OF A SAWN SECTION OF THE VERTEBRA, at the region of the occurrence of the osteoma, showing how the pathological structure grew out of the body of the vertebra.

FIG. 20. TIBIA AND FIBULA WITH TARSAL BONES OF *Limnocyon potens*, a carnivore from the Washakie Eocene, showing in the carious roughening and hyperostoses evidences of disease resembling the results of osteomalacia of today. Published through courtesy of Dr. W. D. Matthew.

bones, were persistent as may be seen in cases of caries and alveolar osteitis with the associated forms of necrosis. It is to be expected that the paleontological evidences of disease would be rather scanty during the Eocene and in fact not a great deal is known. One interesting indication of a pathological condition may be seen in the tibia, fibula and associated tarsal bones of *Limnocyon potens*, a creodont carnivore from the

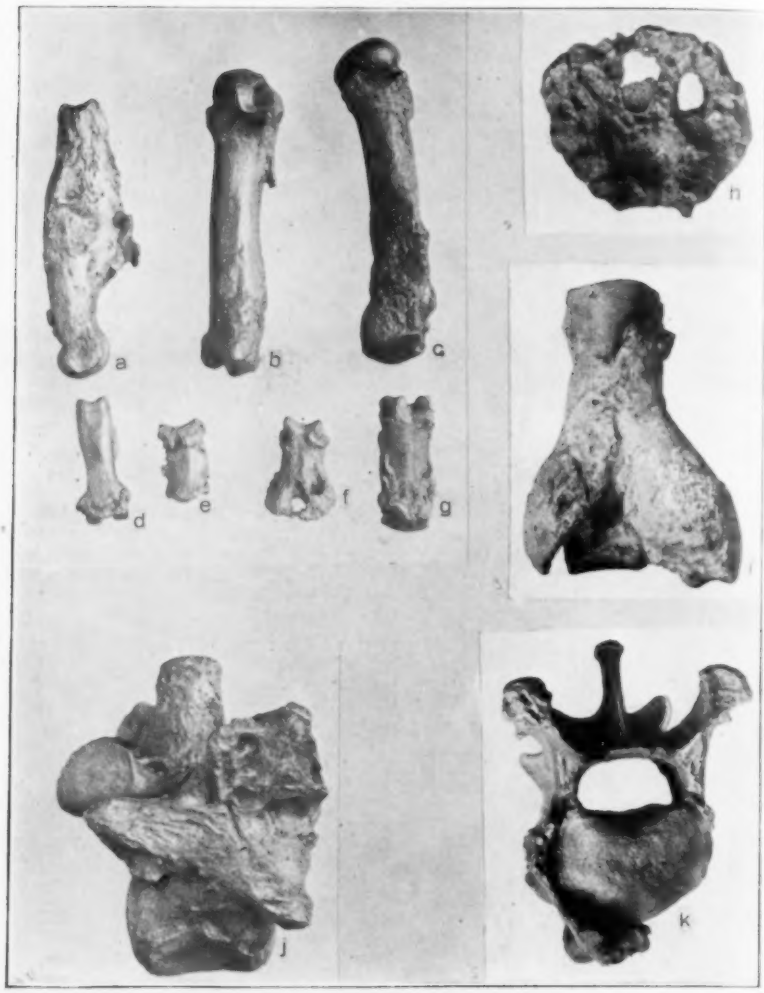


FIG. 21. *a*, metatarsal of a giant wolf, *Canis dirus*, from the Pleistocene, Rancho la Brea beds, of southern California showing a fracture of the middle of the bone with repair and the ensuing callus and exostoses. *b*, metatarsal of a saber-toothed cat, *Smilodon*, from the same deposits, showing on the upper right-hand surface a sharp exostosis, doubtless due to the infection of a tendon sheath, or some similar irritation. *c*, another metatarsal of a saber toothed cat from the same beds, showing on the lower end of the bone considerable carious roughening and hyperostosis. *d*, *e*, *g*, phalanges of a giant wolf showing slight exostoses due to some infection. *f*, phalange of a wolf. In the lower end the erosions of chronic osteomyelitis (?) or some similar long standing necrosis, produced by infection. An end view of this phalange, enlarged, is shown in *h*. *h*, end view of phalange (enlarged) shown in *f*, giving a clear idea of the necrosis produced by the infection. *i*, a pathologic camel phalanx from the Rock Creek beds (Pliocene or early Pleistocene) of Texas. This specimen has been discussed by Troxel (*Amer. Journ. Sci.*, XXXIX., p. 626, 1915) where he says: "Possibly the disease which caused the death of the individual also contributed to the destruction of the species." A supposition which is not supported by the evidence, since the pathological condition as seen in this single phalanx would have caused merely a stiffness and consequent lameness of the foot. Photo published by courtesy of Dr. R. S. Lull. *j*, vertebra of a saber toothed tiger from the Rancho la Brea beds of southern California, showing necrosis in the process seen on

Washakie Eocene. These bones (Fig. 20) show considerable exostoses and hypertrophy indicating an infection of some duration. The appearance of the bones suggests modern conditions of nutritional disturbances resulting in the softening and lightening of the bones as in osteomalacia.

OLIGOCENE

The mammals of the Oligocene suffered from disease and injury, though not so greatly as their successors, nor were any of the diseases prevalent at that time of sufficient importance to produce extinction. It must be remembered, however, that paleontological evidences of the antiquity of disease deal with hard parts exclusively, the soft parts known not being pathologic. The Oligocene dog, *Daphænus felinus*, so carefully and beautifully described and figured by Hatcher[6] presents on the inferior portion of both radii a symmetrical tumor-like mass, the only example of duplicate exostoses in fossil animals. The nature of the exostosis is problematical and I have not been able to find a parallel for this condition among the lesions on human bones. An excellent example of fracture with resulting callus formation and a splendid pseudarthrosis is known in a rib of the right side of *Titanotherium robustum* a perissodactyl from the White River beds of South Dakota, described by Osborn.[7] A careful account of this interesting fracture has been given by the writer,[8] accompanied by a detailed illustration of the callus.

MIOCENE

As an example of the nature of disease during the Miocene may be mentioned the nature of the lower jaw of the type skeleton of *Merychippus campestris*, a three-toed horse from the Loup Fork beds of South Dakota. One ramus of the jaw has a prominent swelling indicating the presence of a long-standing infection possibly of actinomycosis in its early stages, before the eruption of the bone took place. Alveolar osteitis with the

the upper right hand spine. *k*, end view of vertebra of saber tooth from the same beds, showing on the ventral surface of the body of the vertebra pathologic lesions of *spondylitis deformans*. Doubtless a series of vertebrae were ankylosed by the lesion, since the part shown is broken square across. Lesions of spondylitis deformans are fairly common in the mammalian remains of the Pleistocene.

[6] "Oligocene Canidæ," *Mem. Carnegie Museum*, Vol. 1, no. 2, p. 85, pl. XIX., figs. 9 and 11.

[7] *Bull. Amer. Mus. Natl. Hist.*, Vol. VII., p. 347, 1895.

[8] *Annals of Medical History*, Vol. I, No. 4, 1918.

formation of some osteophytes, resembling the results of pyorrhea are also seen, and one molar tooth is afflicted with caries, a common occurrence among fossil animals.

Pliocene, Pleistocene and Recent

The pathological conditions found among the mammals of the Pliocene, Pleistocene and Recent geological periods were the first known and have been extensively described and studied by a number of writers from Esper (1774) to Virchow (1895). There are about twenty contributions dealing with the diseased nature of bones from these periods. A review of our knowledge, especially of the pathology of fossil man, has been given elsewhere[9] and little need be said here concerning the pathological evidences from these periods. A few examples of diseased and injured bones from the Pleistocene, Rancho la Brea beds of southern California shown in Fig. 21, a–k, will give an idea of the prevalence of disease in the bones from these periods.

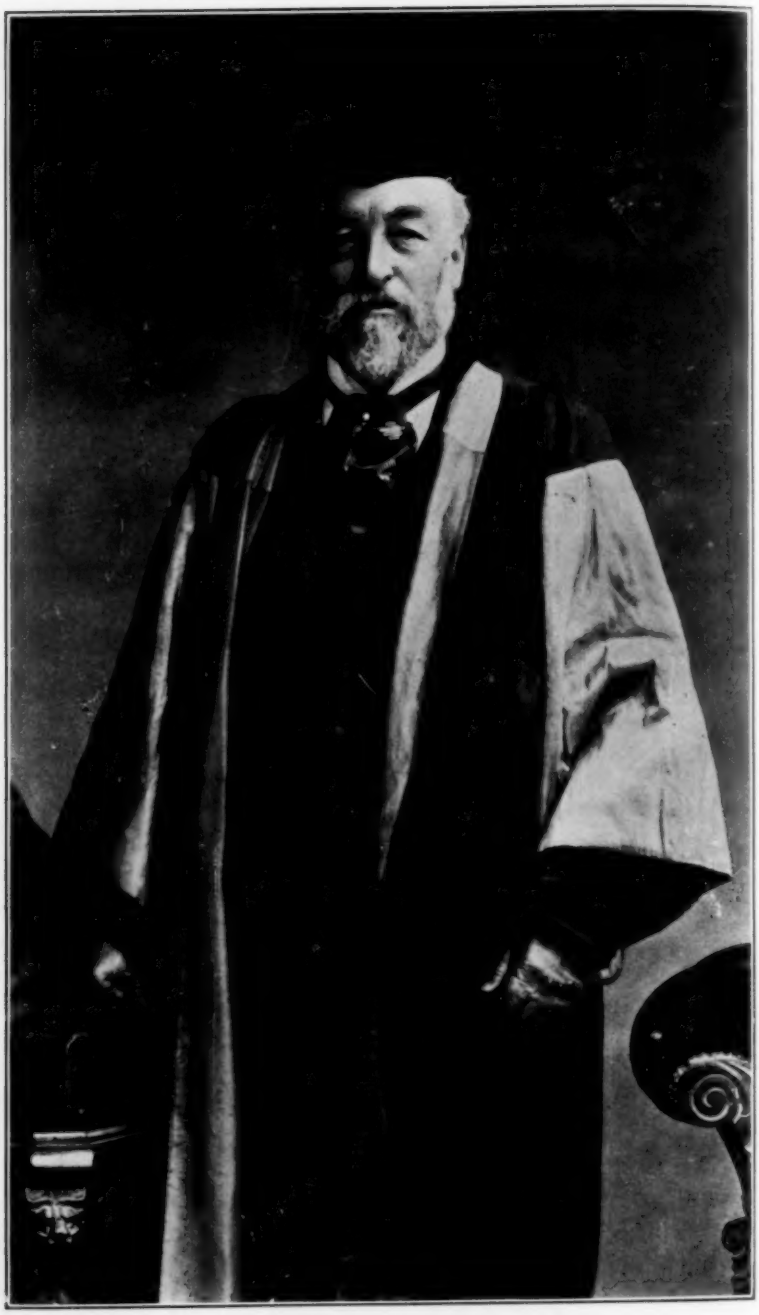
Summary

The above brief summary of paleontological evidences shows that in each geological period there are a few evidences of pathological processes known, although there has been no organized search made for diseased remains. In fact paleontologists as a rule have paid very little attention to evidences of pathology in fossil remains, though the subject is one which yields much that is interesting. The subject increases our vision as to the possibilities of medical history and extends our knowledge of the occurrence of disease back into geological time for many millions of years. No new ideas of pathology have been seen in the study of these ancient lesions—nor were any expected. Since the organization of animal and plant forms of ancient times differ in minute details only from those of recent times there is no reason why we should expect any new ideas. Doubtless many of the lesions described and figured above will on closer examination prove to be lesions of extinct diseases. We know from medieval history that diseases do become extinct and doubtless many of the diseases from which ancient animals suffered are now extinct. Their results, however, as seen in the fossilized bones, closely parallel the pathological anatomy of recent times.

[9] "Studies in Paleopathology. II., Pathological Evidences of Disease among Ancient Races of Man and Extinct Animals," *Surgery, Gynecology and Obstetrics*, 1918, figs. 1–45.

The question of extinction is still an open problem. A study of the paleontological evidences of disease, as seen in the bone lesions, does not help us much yet in an appreciation of what part disease may have played in extinction. The part may have been great, but this is a hypothetical assumption, based purely on analogy.

The subject of paleopathology and the significance of its study were first commented upon and developed by Sir Marc Armand Ruffer, while studying the lesions seen in Egyptian mummies. A study of fossil lesions is merely an extension of the work began by him but it broadens perceptibly the scope and value of paleopathology.



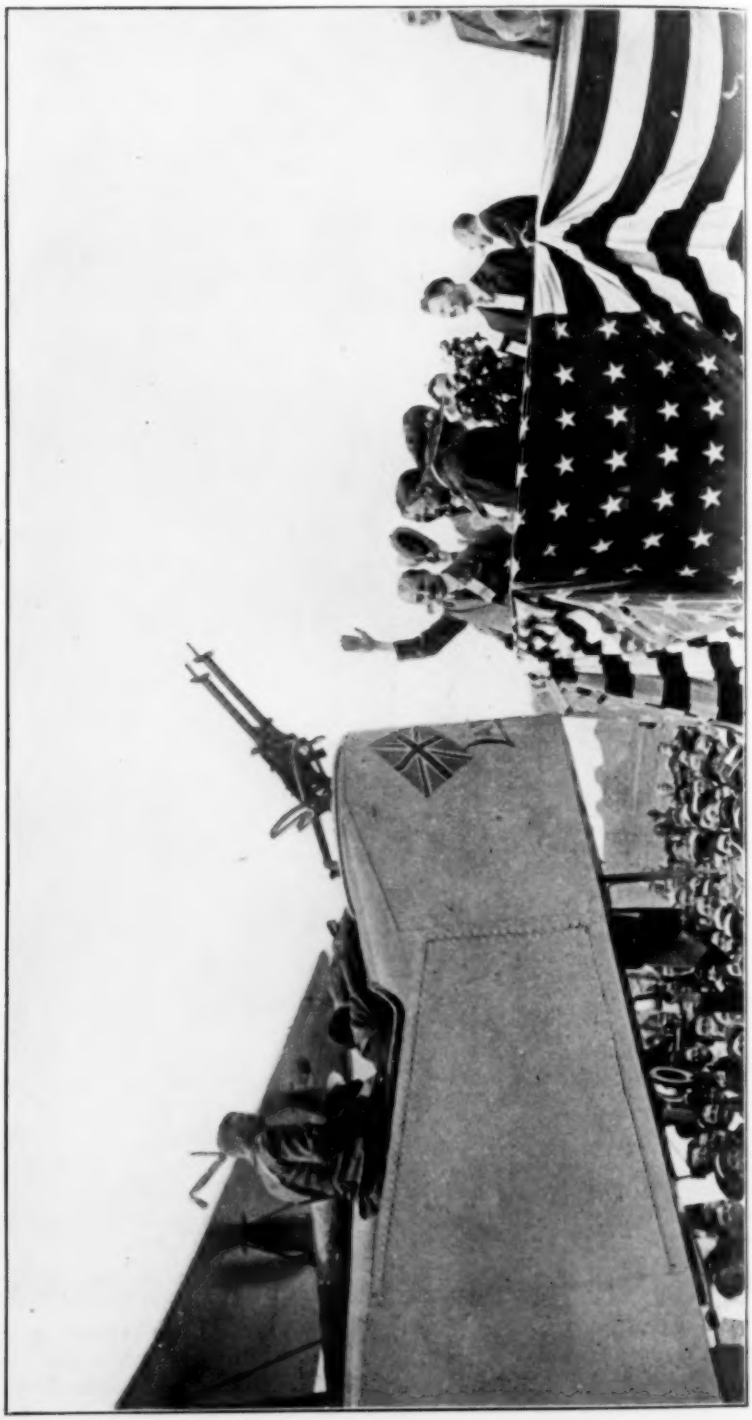
SAMUEL PIERPONT LANGLEY

THE "LANGLEY" IN FLIGHT

THE PROGRESS OF SCIENCE

THE LAUNCHING OF THE "LANGLEY"

FOR three inventions that have transformed modern warfare, the aeroplane, the submarine and the automobile, this country is in large measure responsible. Like other inventions, they have had a long course of evolution contributed through centuries by many lands, but the critical advances appear to have been made here. In the case of the automobile, including the truck and the tractor, and of the telephone, also of prime importance in warfare, the use has been most extensive in America. The aeroplane and the submarine, at present of use chiefly in warfare, have naturally had their principal development among the nations at war. But what has been accomplished here with the automobile and the telephone will be accomplished with



CHRISTENING OF THE "LANGLEY"

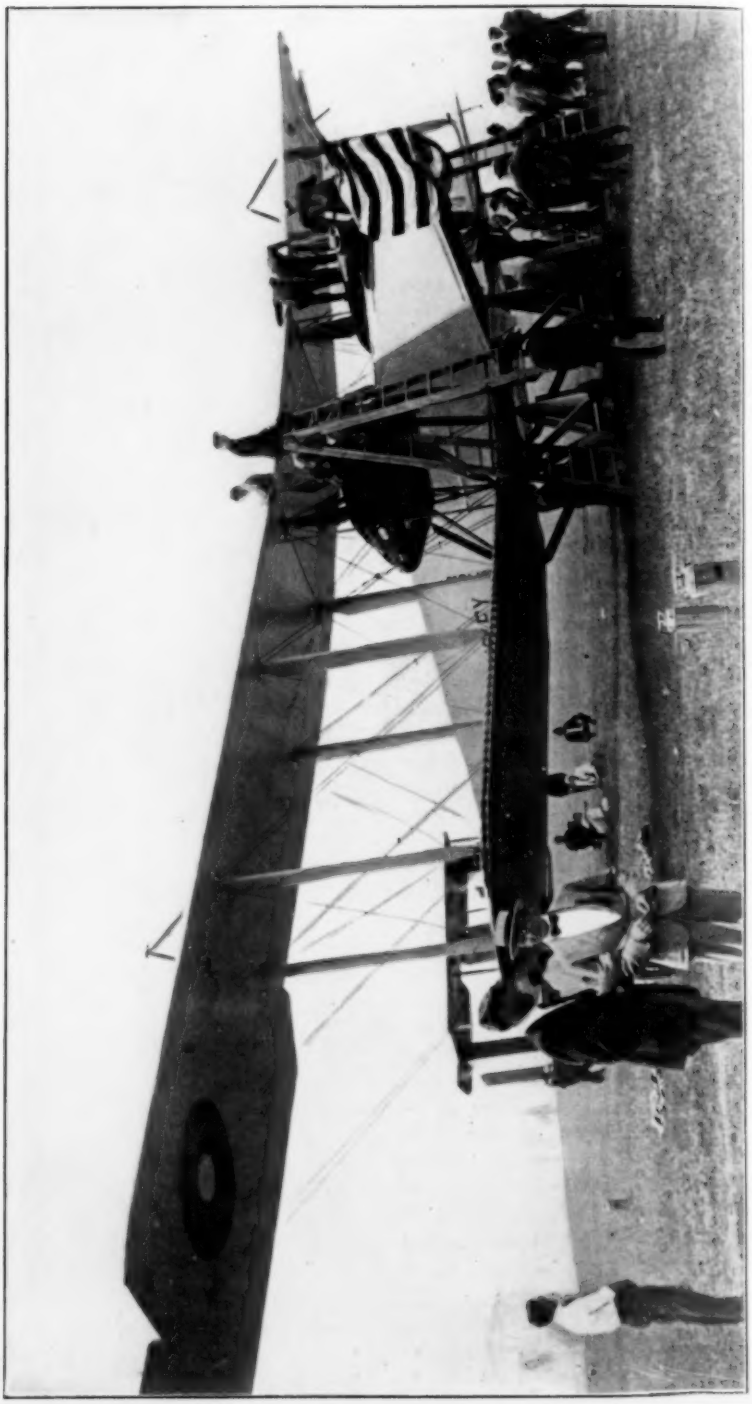
the aeroplane and the submarine, since they have become a necessity to us.

The production of aeroplanes on a large scale and the scientific research which created the aeroplane have been linked together by giving the name "Langley" to the first Handley-Page bombing machine built in America. This huge machine was launched on July 6 from the yards of the Standard Aircraft Corporation at Elizabeth, New Jersey. According to *Flying*, speeches were made by President Mingle, of the company, Assistant Secretary of War Crowell, Mr. John D. Ryan, director of aircraft production, and General William L. Kenly, director of military aeronautics, Sir Henry Fowler, representing the British government, for whom the machine was built, and Mr. Langley, nephew of Samuel Pierpont Langley, who said:

"My uncle, Professor Langley, was not more than fifteen or sixteen years old, while lying under a tree in the field, he gazed up and saw a hawk flying, and he said, 'If a hawk can fly, men can.' Twenty years later he took up that problem and put his whole efforts to investigate the action of plane surfaces, and he said, 'what were the vital facts that we must know,' and it was this first investigation of the air action upon plane surfaces that brought him to the attention of scientists, and they said, 'go ahead.' Since that time the world has been very kind in acknowledging his researches; for the application of his principles by the men of America and every other nation has now produced actual flying machines according to the calculations that he set down."

The Handley Page, with a wing spread of 100 feet and driven by twin Liberty motors of 400 horsepower each, has a range of 600 flying miles with an average speed of 90 miles per hour. The aeroplane

AERODROME IN FLIGHT, 1906



THE HANDLEY-PAGE BOMBING MACHINE, THE "LANGLEY"

is of the O-400 type and was put into production in April. Without its cargo of bombs, the machine weighs 9,000 pounds and to drive it requires fuel consumption of approximately sixty gallons an hour. The Liberty motors are in an armored compartment on either side of the fuselage. In addition to its bombs, the machine also mounts two light Browning machine guns, which can be fired from any desired angle.

Samuel Pierpont Langley, secretary of the Smithsonian Institution, died on February 27, 1906, at the beginning of the era of mechanical flight to which his researches had so largely contributed. In 1905 the Wright Brothers remained in the air for half an hour but it was not until 1908 that they fully demonstrated the practicability of sustained flight. Langley began his experiments when he was director of the Allegheny Observatory, and in 1887 carried on experiments with free flight models. He showed as the result of experiment and theory that one-horse power would propel and sustain in horizontal flight at the velocity of about forty miles an hour somewhat more than two hundred pounds. In 1901 Langley began the construction of a light steam-engine as a motor. Daimler had invented the internal combustion engine in 1885, but it was necessary to await for the development of the automobile to demonstrate the remarkable combination of power and lightness in an engine which has made possible the contemporary aeroplane. Mr. Langley was, however, able to construct an aerodrome, as he called it, which weighed about 44 pounds and which flew for half a mile on May 6, 1896. In 1898 the War Department appropriated $50,000 for experiments with a man-carrying aerodrome. After many experiments and after overcoming many difficulties, the attempt was made to launch the aerodrome, with Mr. Manley as aviator, on October 7, 1903. Owing to defects in the launching the trial ended disastrously, and Mr. Manley narrowly escaped drowning. The experiment was repeated on December 8, when again the launching gear was at fault, and the aerodrome had no opportunity to demonstrate its power of flight. Owing mainly to ridicule in the newspapers and the fear of its effect on the Congress, the Army Board was unwilling to continue the work. The Langley aerodrome, however, with a new engine flew over Lake Kenka in June, 1918.

ANCIENT ARMOR ADOPTED TO MODERN WARFARE[1]

THE war has brought back into use many discarded weapons and practices of medieval warfare. This is shown in the adoption of steel helmets by all the warring powers; in the use of heavy breastplates by the Germans, and lighter breastplates, for attack, by the English; in the armored waistcoats used by the Italians and in trench shields which all the armies are using. Because of this it has become desirable to review the entire study of ancient armor, to which for centuries some of the greatest artists and scientists gave their best efforts. To such masters of the science of armor design as Leonardo, Guilio Romano, Cellini, Holbein, Duerer, Michael Angelo, and others, are ordnance experts of today turning for guidance and inspiration. In fact, it can be stated that so completely were armored defenses studied in the past that today there is scarcely a technical idea brought forward which was not worked out in elaborate detail by the old-time armor makers.

Fortunately for the Ordnance Department, one of the greatest collec-

[1] Publication authorized by the War Department.

tions of ancient armor in the world, accessible to study by the American armor designers, is in the Metropolitan Museum of Art in New York City. This collection, ranking probably seventh in the world, now includes the famous Riggs Collection, which represents the life work of a wealthy student of the subject, and includes some of the richest and rarest pieces that have been in the market since 1850. It is as an incident to this collection that there was established at the museum an armorer's workshop. So far as is known it is unique. It was established for the purpose of cleaning, repairing, or, in rare cases, restoring pieces that were defective. To this end the museum has studied exhaustively the processes of making armor, and has collected from all parts of the world the tools of the ancient armorer's art.

When the war broke out, learning that the government was in need of skilled makers of models for the preparation of armor, Director Robinson, of the Metropolitan Museum, with the sanction of the trustees, placed the department of armor at the disposition of Secretary of War Baker. Since then numerous designs have been carefully worked out by Major Dean and actually made by Tachaux and his young French assistant, Sergt. Bartel, now of the Ordnance Department.

Major Dean, himself, was brought into the service of the Army in November, 1917. Owing to his lifelong study of the subject he was commissioned as a major and sent abroad at once to report on the status of armor. He returned to the United States late in January and has kept the armor workshop of the museum busy, week days and holidays, turning out models in accordance with the suggestions of General Pershing and the Ordnance Department. No less than 25 different types of armor defenses have been made in various factories in experimental lots, including in number from a few score to many thousand pieces, some of which have found favorable comment at American headquarters. These armor defenses include even arm and leg guards, the use of which was suggested by the study of hospital statistics in France and England. It appeared that more than 40 per cent. of the hospital casualties suffered were leg wounds, and no less than 33 per cent. arm wounds.

In connection with this work every effort has been made to improve the character of metal used in the armor making. A committee of the National Council of Defense, including the names of such armor experts as Alexander McMillan Welch, Edward Hubbard Litchfield, Ambrose Monnell, Dr. G. O. Brewster, and Clarence H. Mackay, has dealt especially with the problem of personal armor. And some of the most eminent metallurgists of the country, including those on the committee, have devoted almost their entire time to the question. Among these is Professor Henry M. Howe, of Columbia University, who has made an exhaustive study of helmet metal, aiming to give the American soldier better protection than the soldier of any other nation.

SCIENTIFIC ITEMS

WE record with regret the death of Richard Rathbun, assistant secretary of the Smithsonian Institution, in charge of the National Museum; of Henry Shaler Williams, emeritus professor of geology at Cornell University; of John Duer Irving, professor of economic geology at Yale University, while engaged in war work in France; of Henry George Plimmer, professor of comparative pathology in the Imperial College of Science and Technology, and of Ludwig Edinger, director of the Neurologic Institute of Frankfort-on-Main.

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The Smith-Hughes Act from a Layman's Standpoint, Paul Kreutzpointner.
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THE ZONE POSTAL RATES

Owing to its national circulation, THE SCIENTIFIC MONTHLY is heavily taxed by the new law imposing zone rates on the advertising parts of second-class matter. This law appears to be unfortunate from the point of view of maintaining national interests and national unity. It is desirable that readers who share this point of view should write to congressmen and senators from their states urging the repeal of the zone law. The question is clearly stated in the following letter from the Honorable Charles E. Hughes addressed under date of June 17, 1918, to the Publishers' Advisory Board:

In answer to your letter, I beg to say:

I prefer not to accept a retainer to appear before legislative committees upon matters of general policy, as in such matters, if I have anything to say I desire to speak only as a citizen.

I have no hesitation in saying that I regard the zone system of postal rates for newspapers and periodicals, coming under the definition of second-class mail matter, as ill advised. The Commission on Second-Class Mail Matter (appointed in 1911), of which I was a member, considered this question and reported unanimously against the zone system. We said in that report:

> "The policy of the zone rates was pursued in the earlier history of our post office and has been given up in favor of a uniform rate in view of the larger interest of the Nation as a whole. It would seem to the Commission to be entirely impracticable to attempt to establish a system of zone rates for second-class matter. * * *
>
> "Progress in the post office, with respect, both to economy in administration and to public convenience, leads away from a variety of differential charges to uniform rates and broad classifications."

In my judgment the zone system for second-class mail matter is unjust to the publisher and unjust to the public. It not only imposes upon the publisher the additional rates upon a sectional basis, but it makes necessary the added expense for the necessary zone classifications at a time when every economy in production and distribution is most important. It introduces a complicated postal system to the inconvenience of the publisher and public when there should be a constant effort toward greater simplicity. There is no more reason for a zone system of rates for newspapers and magazines than for letters.

Newspapers and magazines are admitted to the second-class postal rates on the well established policy of encouraging the dissemination of intelligence, but a zone system is a barrier to this dissemination. If it is important that newspapers and magazines should be circulated, it is equally important that there should not be sectional divisions to impede their general circulation through the entire country.

We are proud at this moment of our united purpose, but if we are to continue as a people to cherish united purposes and to maintain our essential unity as a nation, we must foster the influences that promote unity. The greatest of these influences, perhaps, is the spread of intelligence diffused by newspapers and periodical literature. Abuses in connection with second-class mail matter will not be cured by a zone system of rates. That will hurt the good no less than the bad, and perhaps some of the best sort of periodical literature will be hit the hardest.

We do not wish to promote sectionalism, and "one country" means that in our correspondence and in the diffusion of necessary intelligence we should have a uniform postal rate for the entire country. The widest and freest interchange is the soundest public policy.

I hope that Congress will repeal the provision for the zone system which is decidedly a looking-backward and walking-backward measure.

Very sincerely yours,

(Signed) CHARLES E. HUGHES

The Scientific Monthly

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